Universitat Autònoma de Barcelona

All that Glitters is Not Gold
Energy Efficiency from a Critical Policy Perspective

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Ph.D. Dissertation

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"Energy efficiency is an uncomfortable utterance that cries out to be unpacked and better understood."

(Lutzenhiser, 2014)

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Summary

Energy efficiency is an important energy policy strategy globally to reduce energy consumption, secure energy supply, and reduce greenhouse gas emissions. On a global scale, however, energy demand is rising and climate mitigation targets are not being met. There is an acknowledgement by scientists that these challenges cannot be viewed as simply technical in nature but rather the product of collective social and cultural factors. Therefore, more social science research is needed to support an energy transition towards cleaner energy sources. At a first glance, energy efficiency may appear to be a straightforward concept. The idea is that one is saving energy by using less – generally through improved technology or austere practices. This thesis demonstrates, however, that on a deeper level, energy efficiency is a complex and multifaceted concept from both a technical and conceptual perspective. There is a need to disentangle the various meanings of energy efficiency from a social science perspective, including, critically, its conceptual foundations and practical applications. This PhD thesis aims to tackle these ambiguities by studying in detail not only how energy efficiency measurements are conceived of and produced, but also why they are applied and used in a certain way. This is to develop an understanding of the underlying values and motivations inherent in efficiency measurements, and how they are enacted together with social, political and economic processes – and for whose gain. Bringing together insights from Critical Policy Analysis and Science and Technology Studies (STS), the dissertation builds on the work of efficiency and energy social scientists to illustrate what we need to do in order to bridge a conceptual gap in the energy efficiency literature, and in practice. It does this firstly through a social sciences and humanities (SSH) conceptual literature review which identifies a key research gap at the nexus between methodological 'technical', quantitative challenges in energy efficiency together with sociological considerations. The thesis thus goes about filling this research gap through a historical discourse analysis of EU energy efficiency policy which shows that energy efficiency is often used as a 'free lunch' rhetorical device to gain support for policy, and that the way energy efficiency is defined and expressed through indicators conceals underlying social and environmental tradeoffs in policy implementation. Finally, a contemporary case study of EU energy efficiency policy illustrates how the concept of energy efficiency is depoliticised through policy 'tools' including bureaucratic documents and practices. Overall, the dissertation uses these results to pinpoint weaknesses in the energy efficiency literature and in policy, and makes recommendations on how the concept can be reformulated to avoid problematic tradeoffs, and to ensure that uncomfortable but necessary conversations are not kept off the table. A key finding is that moving more towards 'sufficiency' principles (a less technocratic approach) would help energy efficiency

policy reach its intended aims and that citizen participation in policy would generate more sustainable and effective policy in the longer term, particularly regarding subjective and values-based decisionmaking.

Resumen

La “eficiencia energética” es una estrategia política importante a nivel mundial para disminuir el consumo de energía, asegurar el suministro de la misma y reducir las emisiones de gases de efecto invernadero. Sin embargo, la demanda energética sigue aumentando y los objetivos para la mitigación de los efectos del cambio climático no se están cumpliendo. Los científicos admiten que estos retos no deben analizarse solo desde una perspectiva técnica, sino que hay que tener en cuenta factores sociales y culturales colectivos. Por lo tanto, necesitamos más investigación en ciencias sociales para apoyar una transición energética hacia fuentes menos contaminantes. A primera vista, la eficiencia energética puede parecer un concepto sencillo: ahorro de energía a través de tecnología más avanzada o prácticas de consumo austeras. Esta tesis demuestra sin embargo, que en un nivel más profundo, la eficiencia energética es un concepto complejo y multifacético, tanto desde una perspectiva técnica como conceptual. Existe por tanto la necesidad de revisar los diversos significados de este concepto desde la perspectiva de las ciencias sociales, incluyendo de manera crítica sus fundamentos conceptuales y aplicaciones prácticas. Esta tesis doctoral tiene como objetivo abordar estas ambigüedades y estudiar en detalle no solo cómo se conciben y producen las decisiones sobre eficiencia energética, sino también por qué se aplican y utilizan de una manera u otra. Nos proponemos desarrollar una comprensión de los valores y las motivaciones subyacentes e inherentes a las mediciones de eficiencia. También atender a cómo se dictan las leyes al respecto en medio de procesos sociales, políticos y económicos específicos para dilucidar quién es el beneficiario final de estas. Esta tesis propone trazar una línea para llenar la brecha conceptual que existe entre la literatura científica y la práctica, y se sostiene sobre el trabajo de científicos sociales en eficiencia y energía basándose en las perspectivas del Análisis Crítico de las Políticas (CPA) y de los Estudios de Ciencia y Tecnología (STS). La presente tesis doctoral aborda en primer lugar una revisión de la literatura conceptual de las Ciencias Sociales y Humanidades (SSH) que identifica una brecha de investigación clave en el nexo entre los desafíos cuantitativos o técnicos-metodológicos de la eficiencia energética junto con consideraciones sociológicas. Esta investigación trata de llenar este hueco a través del análisis del discurso histórico de la política de eficiencia energética de la Unión Europea (UE) que demuestra que este concepto se utiliza a menudo retóricamente para obtener apoyos políticos, y que la forma en que la eficiencia energética se define y expresa –a través de indicadores– oculta las externalidades negativas subyacentes en la implementación de políticas, tanto en términos medioambientales como sociales.

Finalmente, un estudio de caso contemporáneo de la política de eficiencia energética de la UE ilustra cómo este concepto se despolitiza a través de herramientas en las políticas públicas que incluyen documentos y prácticas burocráticas. En general, esta tesis utiliza estos resultados para identificar las debilidades en la literatura especializada y en la política de eficiencia energética, y hace recomendaciones sobre cómo se puede reformular el concepto para evitar consecuencias problemáticas y para garantizar que las conversaciones incómodas –pero necesarias – no queden fuera de la mesa de diálogo. Un hallazgo clave es que avanzar más hacia los principios de suficiencia ayudaría a que la política de eficiencia energética alcance sus objetivos previstos. A su vez, que la participación ciudadana en la política generaría una política más sostenible y eficaz a largo plazo, particularmente en lo que respecta a la toma de decisiones subjetiva y basada en valores.

Resum

L'«eficiència energètica» és una estratègia política important a escala mundial per disminuir el consum d'energia, assegurar-ne el subministrament i reduir les emissions de gasos d'efecte hivernacle. Però, la demanda d'energia segueix augmentant i els objectius per a la mitigació dels efectes del canvi climàtic no es compleixen. Els científics admeten que aquests propòsits no han d'analitzar-se només des d'una perspectiva tècnica, sinó que tenint en compte factors socials i culturals col·lectius. Per tant, necessitem més investigació en ciències socials per recolzar una transició energètica cap a fonts d'energia menys contaminants. A primera vista, l'eficiència energètica pot semblar un concepte senzill: estalvi d'energia a través de tecnologia més avançada o pràctiques de consum austeres. Aquesta tesi demostra, tanmateix, que en un nivell més profund, l'eficiència energètica és un concepte més complex i multifacètic, tant des d'una perspectiva de les ciències socials, incloent-hi de manera crítica els seus fonaments conceptuals i aplicacions pràctiques. Aquesta tesi doctoral té com a objectiu abordar aquestes ambigüitats i estudiar al detall no només com es produeixen les mesures d'eficiència energètica, sinó també per què s'apliquen i es fan servir d'una manera o una altra. Ens proposem desenvolupar una compressió dels valors i motivacions subjacents i inherents a les mesures d'eficiència. També atendre a com es dicten les lleis al respecte en mig de processos socials, polítics i econòmics específics per esbrinar qui és el beneficiari d'aquestes. Basant-nos en les perspectives de l'Anàlisi Crític de les Polítiques i dels Estudis de Ciència i Tecnologia (STS), aquesta tesi se sosté sobre el treball de científics socials de l'eficiència i l'energia i suggereix traçar una línia per omplir la bretxa conceptual que hi ha entre la literatura científica sobre l'eficiència energètica i la pràctica. Aquesta tesi doctoral aborda, en primer lloc, una revisió de la literatura conceptual de les ciències socials i les humanitats (SSH) que identifica una bretxa d'investigació clau en

el nexe entre els reptes quantitatius o tècnic-metodològics a l'eficiència energètica junts amb consideracions sociològiques. D'aquesta manera, la tesi intenta omplir aquest vuit d'investigació a través d'una anàlisi del discurs històric de la política d'eficiència energètica de la Unió Europea (UE) que mostra que l'eficiència energètica s'utilitza sovint retòricament per obtenir suports polítics, i que la forma en què aquest concepte es defineix i expressa – mitjançant indicadors – amaga les externalitats negatives subjacents a la implementació de polítiques, tant en termes de medi ambient com a socials. Finalment, un estudi de cas contemporani de la política d'eficiència energètica de la UE il·lustra com el concepte d'eficiència energètica es despolititza a través d'eines a les polítiques públiques que inclouen documents i pràctiques burocràtiques. En general, aquesta tesi utilitza aquests resultats per identificar les febleses a la literatura i a la política d'eficiència energètica, i fa recomanacions sobre com es pot reformular el concepte per evitar conseqüències problemàtiques i per garantir que les converses incòmodes, però necessàries, no quedin fora de la taula de diàleg. Una troballa clau és que avançar més cap als principis de suficiència ajudaria al fet que la política de l'eficiència energètica arribi als objectius previstos. A la vegada, que la participació ciutadana a la política generaria una política més sostenible i eficaç a llarg termini, particularment a l'hora de la presa de decisions subjectives i basades en valors.

Chapter 1 - Introduction

1.1 The problem

As this thesis is being written, Europe is in an energy crisis – one in a long succession since the oil crises of the 1970s. Already in 2021, before Russia's invasion of Ukraine, wholesale energy prices were hitting record highs amid tight demand. The conflict has since exacerbated inflation, putting pressure on retail consumers and industry to save more energy. This comes as we face environmental crises due in large part to global reliance on fossil fuels. The Intergovernmental Panel on Climate Change (IPCC) warns that it is 'now or never' to reduce greenhouse gas emissions to keep global warming to a maximum of 1.5°C (Pörtner et al., 2022), while global energy-related CO2 emissions in 2021 are nearing the historic peak set in 2018/2019 of 32.5 gigatonnes (Gt) (IEA, 2021b). A policy strategy that many are counting on to help alleviate the energy crisis is energy efficiency. Headlines of institutional websites read, for example: "Accelerating energy efficiency: What governments can do now to deliver energy savings" (IEA, 2022) and "It is always energy efficiency first" (European Commission, 2022).

Energy efficiency is an important part of European Union (EU) policy with the European Commission having adopted the Energy Efficiency Directive (EED) 2012/27/EU. In December 2019, the European Commission reiterated its commitment to prioritize energy efficiency as part of its European Green Deal strategy to achieve carbon neutrality by 2050 (European Commission, 2019). As he was launching the new European Energy Efficiency Platform, E3P in April 2016, the European Commission's DG JRC Director-General Vladimir Šucha said: "I don't think I need to explain […] why energy efficiency is important." (European Commission, 2016a). Statements from high-ranking officials such as this indicate that there is a general understanding that energy efficiency is a self-evidently useful thing to do. Its pedestal in energy and climate policy needs no explanation. But is energy efficiency really the panacea to our energy problems that many believe it to be?

Energy efficiency is generally seen as a 'win-win', as something that helps save you energy and money at the same time. Since the industrial revolution, significant technological advances have led to more efficient machines and appliances such as LED lightbulbs, fuel-efficient cars, washing machines, dryers and dishwashers, as well as a more productive industry. Energy efficiency has enjoyed prominence as a longstanding and core policy objective in energy and environmental policy at all levels of government on a global scale. It is particularly popular as a non-controversial and low-cost strategy to reduce greenhouse

gas (GHG) emissions (Rosenow, Graichen, & Scheuer, 2018; Sorrell, Mallett, & Nye, 2011). Energy efficiency is a concept that straddles the science-policy interface, because of the belief that it has strong scientific basis and its cachet as an effective policy tool in energy and climate policy implementation. If you search for 'energy efficiency' as either a keyword, title or abstract in Scopus, it comes up with over 500,0000 results. According to the IEA, (2021a) global investment in energy efficiency was expected to rise 10% to USD 300 billion in 2021. Since it rose to prominence in policy globally in the 1970s, the pursuit of energy efficiency has been institutionalized in regulations, laws, practices, technologies, understandings, analytics, organizations, and professions at all levels.

Policy figures often claim that energy efficiency helps boost economic growth while at the same time saves energy and reduces carbon emissions. The big picture, however, is not so straightforward. The deployment of energy efficiency strategies in the world's major economies over the past four decades has not resulted in either an absolute or per capita reduction in energy, thanks to economic expansion, more goods production and more demand for end-use services (e.g., heating, lighting) (Bertoldi, 2020). The measurement and policy implementation of energy efficiency is so complex that it is difficult to know with certainty what effects energy efficiency policy has had – in terms of additionality of reduced energy consumption demand, economic savings, social outcomes and reduced carbon emissions (Herring & Sorrell, 2009; Lutzenhiser, 2014). In other words, there are significant unknowns in the science and application of the energy efficiency concept in practice. For example, there has been a decades-long debate about the nature and extent of the 'rebound effect', the mechanism whereby expected savings are reduced (Brockway et al., 2021). What this means is that we may be making less savings from energy efficiency actions than we originally thought. For example, while energy savings may be made in the home with more energy efficient fluorescent lightbulbs, these gains can be offset if the consumer then decides to buy more lightbulbs than originally intended because they use less energy per unit. There are differing perspectives on the nature and extent of the rebound effect, such as what systemic changes occur and the actual amount of reduced energy savings (Ruzzenenti et al., 2019; Turner, 2013; van den Bergh, 2011). For this reason, the long-term efficacy of energy efficiency policies, when applied outside crisis scenarios, has been questioned (Calwell, 2010; Polimeni et al., 2008). Clearly, something in energy efficiency policy is not working. But how do we develop more effective policy, that not only aims to meet its main goals to reduce energy consumption and GHG emissions, but also meets local needs and priorities such as community outcomes, affordability and sustainability as well?

The importance of a social sciences lens

Energy research has been traditionally dominated by the 'hard' Science, Technology, Engineering, and Mathematics (STEM) disciplines (Sovacool, 2014a). A social sciences lens, however, is crucial in the field of energy given that energy systems are socio-technological where changes in energy technologies reshape social practices, values, relationships, and institutions (Miller et al., 2013). Understanding the human and social implications of energy transitions plays a crucial role in ensuring the uptake of technologies and effectiveness of policy implementation (Benjamin K. Sovacool, 2014). This includes the need to investigate the cultural, behavioural, socio-economic and institutional change inherent in such an energy transition. Social scientists, in particular, call for more focus on frames of e.g. ethics (Smith and High, 2017), fairness (Jasanoff, 2018), justice (Sovacool et al., 2016) and history (Grubler, 2012) in energy research. Social scientists have criticized dominant techno-economic approaches to reduce energy consumption as too narrowly focused, calling for research that takes into account more complex social contexts and practices to find solutions (Labanca & Bertoldi, 2018; Shove & Walker, 2014; Wilhite, Shove, Lutzenhiser, & Kempton, 2000).

Sociological perspectives are underrepresented in the energy efficiency field. However, there are notable social sciences contributions. Some of the recent literature has focused on energy efficiency governance from an organizational perspective (e.g., Gupta and Ivanova, 2009; Jollands and Ellis, 2009) and on psychology and economics studies focusing on individual behaviors regarding energy consumption (e.g. Andrews and Johnson, 2016; Lopes et al., 2012). Much of this strand of literature in the EU is focused on attempting to improve policy design including through more stringent energy efficiency targets, tackling monitoring challenges and non-compliance of Member States (e.g., Bertoldi, 2013; Harmsen et al., 2014).

More widely in the energy and economics fields, there have been concerns raised about the perceived effectiveness of energy efficiency strategies in terms of energy savings (Herring, 2006) and reduction in energy demand (Sorrell, 2015). This is because it can be difficult to monitor and attribute energy savings to energy efficiency actions on the ground (Inhaber, 1997; Lopes et al., 2012). Energy efficiency scholars, including notably social scientists, have pointed to a problem with the concept of energy efficiency itself. In particular, a common critique is that energy efficiency actions tend to act more in the economic interest to save money and consumer comfort and convenience rather than as absolute reductions in energy consumption and emissions. For example, Elizabeth Shove (2017) argues that energy efficiency policies reproduce and stabilize unsustainable concepts of service, which in turn generate unsustainable practices (Shove, 2017). She states that concepts and measurements of efficiency are problematic in that they have

become detached and abstracted from the physical situations in which energy is used and transformed. For this reason, by focusing on only specific and technical aspects of energy performance, programmes and policies of energy efficiency necessarily miss what matters, which is focusing on stemming long-term energy consumption trends. At the same time, she argues, the pursuit of energy efficiency is "counterproductive" because energy efficient strategies reproduce specific understandings of the way we live ('service') which may not be sustainable long term (Shove, 2017).

Studies such as these, however, are largely theoretical and the field still lacks empirical evidence to support the claim that the concept of energy efficiency itself is the problem (rather than policy design and implementation) in that it reproduces and stabilizes unsustainable practices - and if so, how. If there really is a problem with the concept, then, how should it be investigated? This thesis takes inspiration from the fields of Critical Policy Studies and Science and Technology Studies (STS), which analyse science, quantification and policy from sociological, political and historical perspectives, showing that science, values and perceptions are inseparable, and therefore must be investigated together. How energy efficiency is conceptualized and applied in policy is a governance issue that shapes energy policy and society. This thesis therefore aims to unpack the sociological aspects of energy efficiency science and policy to better understand how the concept itself is governed. This type of study is important to better understand underlying interests and motivations at play at the science policy interface, and the underlying values and tradeoffs in the enactment of energy efficiency policy, with the end goal to inform policy processes and debates. I propose to do this by analysing energy efficiency: 1) conceptually through the literature to understand how the concept evolved and how it is perceived differently by diverse actors; 2) historically through discourse analysis of EU policy documents and; 3) in a contemporary case study of energy efficiency policy processes and the quantification of energy efficiency. The thesis is structured in 3 main parts that directly address these three aforementioned objectives. Following summaries of the research objectives and theoretical approach, the first section, Chapter 2, is a literature review of energy efficiency from a social sciences perspective. The second section, Chapter 3, is a historical discourse analysis of energy efficiency in Europe. The third section is a case study of energy efficiency policy in the EU between 2016-2018. This is followed by a discussion and conclusions based on the findings of the research.

1.2 Research Objectives

The overall objective of this research is to unravel the ostensible simplicity of efficiency in order to reveal

its ambiguities and contradictions, showing how multiple values and interests are embedded in its use. In this process I also intend to show how measurements are co-produced and constructed with social orders and thus how efficiency measurements are enacted together within energy/environmental governance and economic processes. Thus, the research goes beyond asking *why* energy efficiency is important as a policy tool, indeed, exploring what energy efficiency means itself, and *how* is it enacted in a policy setting. These questions are at the heart of the study and help to understand the complexity of the concept as well as the differing interests involved and who wins and who loses in the politics of energy efficiency policy. The expectation is that by answering these questions, a better understanding of energy efficiency at the science policy interface is achieved in order to inform policy debates and policymaking for more effective, relevant and fairer policy outcomes.

This main objective can be broken down into 3 specific aims. These include:

Aim 1

The first is to better understand how energy efficiency is conceptualised in the literature, where the gaps lie in the energy efficiency field, especially from an SSH point of view. The literature suggests that there is a major gap at the nexus between the SSH and technical methodological issues, and also that there is a lack of understanding of the concept and historical context surrounding its evolution. My objective therefore is to explore this hypothesis and pinpoint if and where the research gaps lie.

Research question:

- **How is energy efficiency conceptualized, both historically and contemporarily, by different actors?**

Aim 2

The second aim is to deploy qualitative theories and tools, including discourse analysis, to reveal hidden power dynamics, interests and forms of argumentation in the enactment of energy efficiency policy. Discourse analysis belongs to the Argumentative Turn group of theories that focus on argumentation, language and deliberation in policymaking and analysis. This group pays attention to the situative context and varying knowledge practices involved in policy. Thus, the aim in using discourse analysis is to reveal

how the underlying values and political and social conflicts are embedded in efficiency policy processes. The idea is to approach policy through a lens of constructedness in the sense that there is a focus on human intersubjectivity and historical context. The aim therefore is to illustrate how policies have a multiplicity of meanings, which are communicated and mobilized in struggles over political power and societal change.

Research question:

- **What are the underlying discourses embedded in the term energy efficiency in relation to EU energy policy?**

Aim 3

The third aim is to investigate energy efficiency indicators and measures to understand underlying meanings and the struggle for power inherent within them, and the way they are produced. The aim therefore is to incorporate both the technical and methodological challenges, together with a SSH lens of indicator politics or politics of quantification, for a mixed methods approach to understand the tradeoffs inherent in energy efficiency policy. The two methods are incorporated together to investigate the co-production of the objects (indicators) and social practices, and, in turn, to understand the social, environmental and economic tradeoffs involved in these processes.

Research question:

- **How are energy efficiency measurements produced?**

1.3 Structure of the thesis

Chapter 1 introduces the topic of the research and the research rationale. Chapter 2 is a literature review, aimed at exploring different conceptualisations of energy efficiency. It aims to assess the literature related to the research question outlined in the previous section. The literature on energy efficiency itself is expansive, numbering some half a million texts in Scopus. Thus, the review of the literature will apply

conceptual focus of the SSH literature. This is to fill in historical and contextual gaps regarding the concept of energy efficiency and make connections between the past, present and perceived future to understand how the term has evolved and why. The review will seek to better granulate the research gaps in the SSH literature. Moving to policy, Chapter 3 takes an historical view of energy efficiency indicators in EU policy. It uses discourse analysis to better understand how EU energy efficiency is used as a rhetorical device, and what the effects of these conceptualisations on policy are. This chapter traces the evolution of EU energy efficiency policy over seven decades to identify underlying values and tradeoffs from a sociological perspective. Chapter 4 is a case study investigating the politics and processes inherent in the passage of legislation to amend the 2012 EU Energy Efficiency Directive between the years 2016-2018. Using insights from research on the politics of measurement and STS, the study aims to fill a gap about the methodological challenges of energy efficiency implementation, together with the political dynamics involved in seeking to know what is quantified, what is left out and what issues co-emerge as energy efficiency is discussed as a quantifiable and governable object. The research aims to better understand the political, societal, and environmental tradeoffs in the quantification of energy efficiency indicators. Chapter 5 draws the findings of the three empirical chapters together. Chapter 6 draws conclusions from the discussion and offers suggestions for the direction of future research.

The three empirical chapters, the focus of research, the main research question and the method used to investigate the question are set out in Table 1 below.

Table 1: Summary of research questions and methods for the three empirical studies

Chapter	Study	Main research question	Method
2	Conceptual literature review of energy efficiency social sciences literature	How is energy efficiency conceptualized, both historically &contemporarily, by different actors?	Scopus search combined with guiding conceptual research questions and criteria to select review texts
3	Historical discourse analysis of EU energy efficiency policy	What are the underlying discourses embedded in the term energy efficiency in relation to EU energy policy?	Discourse analysis (Stone, 2012)
4	Case study of EU energy efficiency policy between 2016-2018	How are energy efficiency measurements produced?	Case study methods; theoretical framework

1.4 Theoretical Underpinnings

Energy efficiency at the science-policy interface

I situate this research within the fields of Critical Policy Studies and Science and Technology Studies (STS). These frames complement each other, in that they deal with contested ideas and values where science and policy intersect. They can help tease out underlying meanings and interests involved in the production and enactment of energy efficiency within the science-policy space. A main focus is how energy efficiency is shaped through actors, institutional-organizational logics and discourses about its use and implementation. In particular, this thesis seeks to elicit insights from discourse analysis (Stone, 2012), indicator politics (Merry, 2016; Turnhout et al., 2014) and enactment of political objects (Asdal, 2008a, 2008b; Callon, 2021; Law, 2009), to investigate the underlying themes, meanings and contradictions inherent in the concept and its application.

Both the fields of STS and the group of critical policy studies known as 'post-positivist policy analysis' treat policymaking as a dynamic space where ideas and values are constantly contested. A key point for critical researchers is the rejection of the traditional conceptualisation of the science policy interface as a straightforward, rational process whereby evidence is presented in a top-down way by decision making authorities to identify problems and solutions as linear and uni-directional (Colebatch, 2005; Jasanoff et al., 1998; Pressman and Wildavsky, 1984). Policy analysts must reject the paradoxical trap of the 'rationality project' which uses conventional, positivist policy science to render policy analysis simplistic and apolitical through the application of rational, managed and simplified analytical methods.

Rather, the relationship between science and policy is seen as complex and dynamic – where science and policy not only cooperate, but are mutually constitutive or 'co-produced' (Jasanoff, 2004). Going beyond the more conventional policy analyses of classical policy science, post-positivist policy methods reveal points of contention among policymakers, including disputes over policy values (Stone, 2002). The critical approach to policy studies considers the relationship between policy and specific practices of governance, especially as they pertain to e.g. democracy, participatory practices, social justice, and public welfare. Critical policy scholars focus on interpretive, argumentative, and discursive approaches to investigate policymaking practices. The 'argumentative turn' (Fischer and Forester, 1993) group of theories focus on argumentation, language and deliberation in policymaking, paying attention to the situative context and varying knowledge practices involved in policy production. Here, the language of

policy is observed to analyze the critical issues of 'truth' and 'power' in the construction of causality, legitimacy and responsibility, interests, needs, values, preferences and obligations.

Discourse analysis, applied in Chapter 3, is a critical policy analysis approach that can uncover the interests and motives behind a policy, by allowing the analyst to view a problem from a higher stance and so studying the underlying meaning of a spoken or written text in its social and historical context. Specifically, I will apply the 'Big D discourse' in the Foucauldian sense rather than the "little d" in the Habermasian sense. The Foucauldian notion of discourse focuses on broad concepts and generalized systems for the formation and articulation of ideas over a particular period of time, while Habermas' theory was more concerned with micro-interaction situations observing how people use language in everyday settings. By applying the 'Big Ds' we come to understand the values and arguments embedded in efficiency policymaking. Taking a broad themed approach, Dryzek (2013) sees discourse as "a shared way of apprehending the world. Embedded in language, it enables those who subscribe to it to interpret bits of information and put them together into coherent stories or accounts." (pp. 9). In expressing the importance of discourse analysis in political studies, Hajer & Versteeg (2005) maintain that "the basic assumption of discourse analysis is that language profoundly shapes one's view of the world and reality, instead of being only a neutral medium mirroring it (pp. 176). Similarly, these authors argue, discursive devises such as metaphors (seeing something in terms of something else) matter because of their ability to reveal the embeddedness of language in practice. Furthermore, the important contribution of discourse analysis is that it can reveal how particular discourses are institutionalized and shape what can and cannot be thought, delimiting the range of policy options and thus helping to funnel policy outcomes (Keller & Poferl, 1998; Litfin, 1994).

The politics of quantification and measurement

Measurement is central to this research. It investigates the quantification of energy efficiency through indicators in order to assess the implicit values, motives and subjectivities in measures. The process of quantification has many philosophical considerations, and numbers are value-laden (Ellis, 1966). Seemingly straightforward measurements, in fact, conceal a host of theoretical and empirical assumptions (Campbell, 1920). Researchers, scientists and policymakers form judgements which govern the manufacture of quantitative measurements and the assessment of their quality, and this process contains historical dimensions (Funtowicz & Ravetz, 1990). Furthermore, epistemological uncertainty remains as to the extent that scientific theories relate to the real world. According to Funtowicz & Ravetz, (1990),

studies of the philosophy of knowledge are often abstract reconstructions that fail to recognize the practical uncertainties of scientific research. In the 19th century, physicists grappled with the philosophical conundrums of measurement, trying to find coherence among instruments and standards and whether theories could be applied to real applications (including notably, electro-technologies)[1]. Similarly in the 18th and 19th centuries, engineers grappled with the practical applications of measuring the efficiency of waterwheels, raising philosophical dilemmas about how to measure matter in motion (Karns Alexander, 2008). Despite these examples, in general the understanding of the historical relation between formal systems and practical operations on the material world – both from an applied and philosophical perspective, has been neglected. In one of the earliest works to scrutinize measurement from a metaphysical perspective, Ellis (1966) found that scientific measurements lacked critical philosophical analysis and debate. Since then, a number of scholars have implored researchers to analyze debates over measurement in their historical context, as a way of detecting the meanings and values embedded in processes and choices (Asdal, 2008a; Porter, 1995; Roberts, 2002; Scott, 1998; Serres & Latour, 1995).

Taking matters into the present, this research seeks to explore the politics behind knowledge production, and, in particular, energy efficiency indicators. From an STS point of view, the production of scientific knowledge involves varying social and cultural factors (Jasanoff et al., 1998; Latour and Woolgar, 1979; Yearly, 1988) and is often 'driven by local, practical, and sometimes openly political interests, [. . .] entrepreneurial, fiercely competitive, wildly speculative and methodologically pluralist, and selling itself to government and big business in the search for financial resources' (Hoppe, 2005 p. 205). Research has shown how scientific knowledge, its production and circulation are closely entwined with economic and political interests. For example, in her work on ecological indicators, Asdal (2008) observes how nature-wholes are quantified, unified and linked to political and economic processes – and how both are enacted together. In revealing the political nature of nature itself, Asdal shows that who is doing the accounting matters, and will in turn shape the way nature itself is conceived (Asdal, 2008a). In other words, "only what is counted counts" (Turnhout, 2014 pp. 594). In a similar vein, Turnhout and colleagues (2014) use the term 'measurementality' to describe the process whereby the environment is classified into units that can be commensurable and exchangeable with other economic and political structures (Turnhout et al., 2014). Echoing Turnhout et al., Martin & Lynch (2009) use the term "numero politics" to refer to a broad range of disputes about particular counts, estimates and measures. These authors state that counting is of prime interest to sociologists because it often constitutes a social problem in that methods of counting

[1] These include E. Mach (Mach, 1883) P.M.M. Duhem (1914), N.R. Campbell (1921), and P.W. Bridgman (Bridgman, 1927).

often become caught up in the political and epistemic conflicts they are used to address. They state that "how a count is produced depends very much on who is doing the counting, what the count is for and the occupational and physical location of the counting event". (Martin & Lynch, 2009 pp. 245). They found that many of the counting practices were specific to the political contexts and disciplinary activities in which they were performed.

Given these findings, the reality is that scientific facts that are intended to be objective and comprehensive may end up creating disputes about the data and its interpretation. Collingridge and Reeve (1986) describe the role of science in policy as paradoxical, because it is intended to close the debate through objective and 'rational' facts, but instead it only enhances debate: The ''relevance to policy, by itself, is sufficient to completely destroy the delicate mechanisms by which scientists normally ensure that their work leads to agreement. Consensus on scientific questions which are more than marginally relevant to policy is therefore impossible'' (Collingridge & Reeve, 1986 pp.ix-x). Turnhout et al. (2007) note that a certain amount of vagueness or ambiguity may contribute to the success of an ecological indicator in a specific context. While this may sound counterintuitive, the argument is that this leaves room for negotiation and reformulation. Calwell (2010) shares a similar view when it comes to energy efficiency, explaining that, although many technologies do not follow a 'linear' measurement approach commonly used in efficiency input/out ratios, policymakers tend to prefer such a linear approach regardless, for the sake of simplicity and the ready ability of spreadsheets to fit lines to data sets. Bowker and Star (2000) even argue for the importance of flexibility and ambiguity in classification systems so as to "leave certain terms open for multiple definitions across different social worlds" (Bowker & Star, 2000 pp. 324). But simplicity may perversely bring with it a lack of transparency and confusion. Bowker & Star (2000) and Turnhout et al. (2009) show that the simplicity of classifications and measurements can make them useful to some actors to conceal uncomfortable knowledge, because until they are broken down, dissected and contested, they are taken for granted and invisible: "The easier they are to use, the harder they are to see" (Bowker & Star, 2000 pp. 33).

These STS findings on the sociology of quantification and ambiguity in science and politics form the theoretical backdrop for this dissertation. These theories provide an ideal lens with which to observe energy efficiency, which, by its definition and quantification, involves a range of subjectivities and value judgements that need to be unpacked, detailed and better understood. So far, there is very little research that systematically combines a study of the methodological challenges of energy efficiency implementation with these kinds of political dynamics to ask questions about what is quantified, what is

left out and what issues co-emerge with the ways energy efficiency is currently discussed as a quantifiable and governable object.

1.5 Method

Each of the three empirical studies has a method tailored to addressing the particular question being investigated. The method employed in each study is set out below

The empirical study in Chapter 2, entitled "Mind the Gap: A social sciences review of energy efficiency", comprised a conceptual literature review, for which 104 articles were selected through a two-step process. Firstly, a list of criteria was developed to identify literature relevant to the research question. These criteria assisted to filter articles found through the search engine Scopus and related references found in the literature. Secondly, a set of guiding research questions was formulated to synthesize the main themes explored in the review (see Chapter 2 for more details). The articles selected included both recent and historic works, included to capture trends and changes in culture, values, technologies and governance priorities over time.

The empirical study in Chapter 3 investigates EU energy efficiency policy historically with relevance to how the concept has changed through time, and seeks to uncover the policy paradoxes involved in this evolution. This study applies the discursive 'methodological toolbox' of Stone (2013) with the aim of revealing the underlying values, justifications and interests that are involved in the process of the production and use of efficiency measurements. This chapter conceptualises energy efficiency as a 'motherhood' issue as the rationale for analyzing underlying values in its use in EU policy. Motherhood issues, according to Stone, are enduring values of community life that are the standards of analysis most commonly invoked in policy debates. While generally supported by everyone in the abstract, these motherhood issues often lead to contradictory interpretations when details are made explicit. Limited to EU policy, 20 policy documents were selected based on their relevance to energy efficiency policy, chosen to provide a comprehensive overview of policy between the 1950s and 2018, the beginning of the research study. A minimum of two documents were chosen from each decade, selected with the aid of criteria used to determine their relevance to policy based on the breadth and depth of their treatment of energy efficiency. An analytical framework of four code elements from Stone's (2013) discursive methodologies was developed:

1) Symbols: verbal languages
2) Numbers: numerical languages
3) Interests: which actors are involved on different sides of a debate
4) Facts: socially constructed information used to persuade

These codes were applied to the documents in three iterations of increasingly fine-grained analysis, which provided data compiled in a note-taking table. The codes were analysed with regard to Stone's guiding research questions regarding efficiency as a motherhood issue: Who gets the benefits and bears the burdens of a policy? How should we measure the benefits and costs of a policy? And what mode of organizing human activity is likely to yield the most effective results? The codes were then used to synthesize the analysis of the discourse.

The empirical study set out in Chapter 4 is a case study of energy efficiency policy in the EU – in particular, the legislative process of amending the EU 2012 Energy Efficiency Directive between 2016 – 2018. The purpose of the study is to chart the political dimensions involved in the enactment of energy efficiency legislation – including the contestations over energy efficiency definitions and measurements, and what the tradeoffs are in implementing one set of definitions and methodologies over another. This chapter takes these political negotiations as a case to explore how the conceptualisation and measurement of energy efficiency is not simply a 'technical' discussion, but one where scientific and methodological aspects are entangled with political, societal and environmental issues to create a governable object that is energy efficiency. A set of analytical tools taken from work within the field of STS is applied, relating to the enactment of realities through material-semiotic practices (Asdal, 2008a, 2008b; Callon, 2021; Law, 2009). The basic assumption is that governance objects like energy efficiency are not simply "out there" as somehow independent and prior to our actions, but rather the outcome of these practices. Procedures and methodologies of quantification and measurement play a particularly important role here. In applying this theoretical framework, the study uses a mixed methods approach whereby the principal sources of data are policy documents and media articles. Interviews with policymakers and energy efficiency practitioners and experts compliment these data, eliciting the reasons why decisions were taken and the arguments made to support them. The main themes of the study were developed iteratively, by first analysing methodological challenges in the literature, and then identifying similar themes in policy documents, media articles and interviews, principally Commission impact assessments, parliamentary reports and amendment proposals and working documents from inter-institutional negotiations known as 'trilogues'. Online news reports were collected from specialized political news outlets covering the passage of the legislation to provide context for the policy documents and to identify external institutional

actors involved in policy discussions. My fieldwork involved travelling to Brussels in March 2018 to meet with the parliamentarians and their assistants, and to France in July 2019 for the Energy Efficiency Summer School, one of the principal energy efficiency conferences in Europe, to meet with energy efficiency practitioners and researchers.

1.6 Main contributions

The three empirical studies that comprise this dissertation have been, or are in the process of being, published in top-reference journals in their respective fields. The first study, a conceptual literature review of energy efficiency, was published in the journal *Energy Research and Social Sciences*. I presented this work at a prominent energy efficiency event in Europe, the *Energy Efficiency Summer Study*, as an oral presentation in 2019. Following the publication of the article, I contributed to a special working group on energy efficiency social sciences research as part of the ENERGY SHIFTS H2020 project to determine the most pressing energy efficiency research SSH questions to present to European Commission policymakers. The second empirical study, a historical discourse analysis of energy efficiency in EU policy, was published in the journal *Social Studies of Science*. I presented this work at the 5th Symposium of Post Normal Science in 2020. The third empirical study was submitted as an article to the journal *Energy Research and Social Science* in 2022 and was presented at the EEAST conference in July 2022.

The main contribution of this dissertation is to propose a critical analysis of the concept of energy efficiency and to reveal underlying values, power dynamics and tradeoffs in the enactment of energy efficiency policy. This is done by applying critical policy analysis and STS insights to EU policy processes. I engage with theories of quantification and governance, policy science and SSH energy studies. In doing so, I contribute to the small but growing body of literature on energy efficiency SSH and, in particular, I propose a new direction for this field in applying quantification and technical measures with a SSH lens to better understand the meaning and tradeoffs inherent in energy efficiency science and policy. I anticipate that the findings of this research will be used as the basis for future policy on energy efficiency in the European theatre, and potentially beyond.

Chapter 2 – A social sciences review of energy efficiency

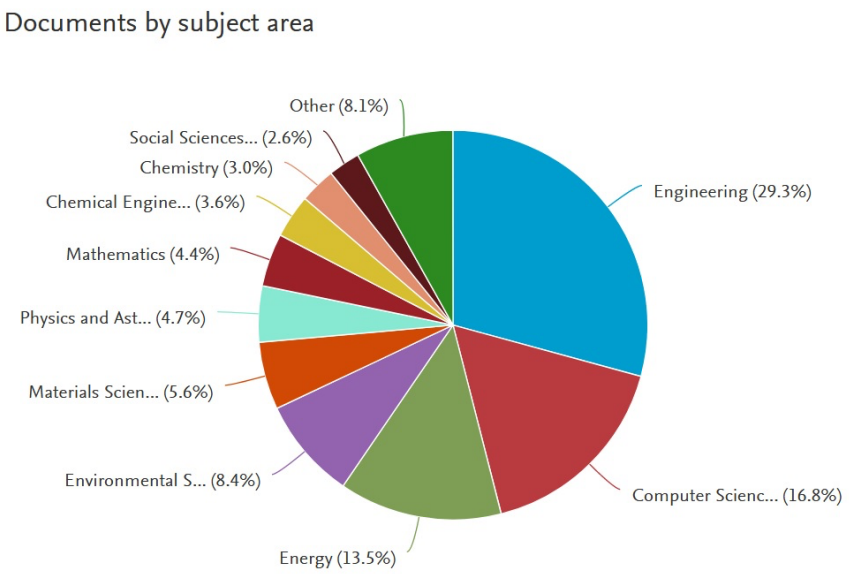
2.1 Introduction

Challenges surrounding energy consumption and energy efficiency remain complex which make effective implementation a challenge in energy policy (Herring and Sorrell, 2009; Lutzenhiser, 2014). Social scientists have criticized dominant techno-economic approaches to reduce energy consumption as too narrowly focused, calling for research that observes more complex social contexts and practices to find solutions (Labanca & Bertoldi, 2018; Shove & Walker, 2014; Wilhite, Shove, Lutzenhiser, & Kempton, 2000). Within this context there are calls to disentangle energy efficiency further, including, critically, its conceptual foundations, practical applications and sociological aspects (Herring, 1995; Princen, 2005; Shove, 2017). As Lutzenheizer (2014, pp.142) states: "[Energy efficiency] is an uncomfortable utterance that cries out to be unpacked and better understood". Just as science and quantification cannot be considered free of human values and perceptions (Porter, 1995), neither can the concept of efficiency (Boulding, 1981; Patterson, 1996; Shove, 2017). Efficiency has historically been conceptualized in various forms, and the specific way that measures and indicators are developed and applied can impact society in different ways (Karns Alexander, 2008; Princen, 2005). These applications of quantitative measures can result in societal tradeoffs for example an unfair burden on consumers (Owen, 1997), a human detatchment from the natural world (Shove, 2017), a distraction from alternative decarbonization measures such as renewables (Ruzzenenti and Wagner, 2018) and paradoxically increased energy use (Herring, 2000). As it stands, many of these tradeoffs are not fully understood. There is very little research that examines energy efficiency from a conceptual perspective taking into consideration both technical (quantitative, methodological) and sociological aspects. In order to address this omission, and building on the work of efficiency and energy historians and social scientists, this chapter aims to observe energy efficiency through a new lens understanding how it is conceptualized, taking into consideration cultural and technological change over time. The aim of this research is not to provide a comprehensive review of the literature but instead to highlight key issues and challenges, pinpoint research gaps and suggest a way forward for more comprehensive and balanced energy efficiency research. Structured in five main parts, the second section explains the methodology followed by a definition section. The fourth and major section divides the literature into four parts, followed by a discussion and conclusion.

2.2 Methods

The literature on energy efficiency covers a broad and diverse spectrum. Searching for the term 'energy efficiency' as either a title, abstract or keyword between the years 1909-2018[2] generated 155,156 document results in Scopus. The Scopus analysis shows the energy efficiency literature breakdown by subject area. The most strongly represented fields were engineering (29.3%) computer sciences (16.8%) and energy (13.5%), with much less research from the materials sciences, physics and the social sciences (see sector breakdown of the literature in Figure 1). Much like trends observed in the energy literature (Benjamin K Sovacool, 2014), the majority of the energy efficiency literature is dedicated to quantitative, technical engineering and economic analyses (Sorrell et al., 2011).

Figure 1. Research body covering 'energy efficiency' in either article title, abstract and keywords from 1909 – 2018 (Scopus).



As this review aims to understand the conceptual issues regarding energy efficiency in particular, a methodology is required to select the literature relevant to meet this aim. Specifically, the research question is: how is energy efficiency conceptualized, both historically and today, by different actors? The search engine (Scopus) did not provide the main method to select articles due to the excessively high number of results that, more often than not, were not relevant to the study (see Table 1 for details). To

[2] Search conducted on 11 December, 2018

sharpen the review, a list of criteria was developed to identify literature relevant to the research question. This criteria was used to filter articles found through the search engine and reference sections of the literature.

Criteria for selecting review literature:

- Works dealing with energy efficiency as the main subject were chosen, rather than those treating energy efficiency as methodology or tool (for example, measuring the efficiency of a heating fan).
- Highly specialized articles on micro-level, empirical applications were omitted (for example, articles such as: "Energy consumption in capacitive deionization – Constant current versus constant voltage operation" were deemed unsuitable).
- Works taking a broader, macroeconomic, global view were favoured (i.e., selecting articles which dealt with energy efficiency within a broader energy policy context rather than more granular articles that dealt with the issue of energy efficiency within a particular field or sector e.g. IT, agriculture, medicine, chemistry, etc.).

Table 1: Scopus search: results numbers tended to be either excessively large or did not meet the review criteria

Search Number	Search terms	Filters	Quantitative Results	Meaningful Results	Problems
1	"Energy Efficiency"	None	155,156	0	Too many results
2	"Energy Efficiency"	Limit to: "Social Sciences"	7,426	0	Too many results
3	"Energy Efficiency" + "Conceptual"	Limit to: "Social Sciences"	68	1	Most articles did not meet criteria
4	"Energy Efficiency" + "Conceptual"	Exclude: "Computer Science", "Chemical Engineering",	484	7	Most articles did not meet criteria

"Physics and Astronomy", "Materials Science", "Earth and Planetary Sciences", "Chemistry", "Agriculture and Biological Sciences", "Decision Sciences", "Biochemistry, Genetics and Molecular Biology", "Medicine", "Immunology and Microbiology", "Neuroscience" and "Health Professions".

Given the various ontological and epistemological perspectives on energy efficiency found in the literature, a set of guiding research questions were used to synthesize the main themes explored in the review (see Box 1 for an overview of these questions).

Box 1. – Research questions that guided the review

Historical (Section 2.4)

- How did the concept of energy efficiency emerge and why?
- How has the concept changed over time?

Implied normativity (Section 2.5)

- What are the benefits of energy efficiency, and how can they be proven?
- What are the counterpoints to these perceived benefits?

Methodological (Section 2.6)

- What are the challenges faced in measuring energy efficiency?
- What aspects can be captured by energy efficiency indicators?

Sociological (Section 2.7 & 2.8)

- How are value judgements manifest in energy efficiency measurements?
- What sociological and environmental aspects does the concept of energy efficiency miss?

While the review focuses specifically on energy efficiency, an exception was also made to include historical development of the use of the separate terms 'efficiency' and 'energy' given the high relevance of these terms in shaping today's understanding of the concept of energy efficiency – and due to the lack of historical discussion dedicated specifically to the topic of energy efficiency. Four historical exceptions were also made due to the fact that the lexicographical expression of the term 'energy efficiency' has changed over time over time (for example in the 1800s there are references to the 'economy' of a machine, and in the 1970s texts refer to 'an efficient use of energy').

The review focuses mainly on academic literature, however in some cases grey literature (e.g. conference proceedings) was included to ensure a diversity of opinion given the lack of conceptual attention to the subject of energy efficiency in the academic literature. Most of the grey literature was found through reference screening, based on the same criteria for other peer reviewed articles. Some grey literature was selected based on whether it represented relevant government organisations and other research or private sector organisations known in the field (e.g. the IEA, European Commission, World Bank).

In total, 104 documents were selected, including both recent and historic works, in order to capture trends and changes in culture, values, technologies and governance priorities over time.

- 8 references were gathered through the Scopus word search
- 95 references were gathered through reference section screening
- 1 updated reference was gathered through expert recommendation

2.3 What is energy efficiency (and what is it not)?

Energy efficiency can be defined as using less energy to produce the same amount of services or useful output (Patterson, 1996). Energy efficiency should be distinguished from energy conservation because the two terms are often used interchangeably, even though they are distinct concepts (Inhaber, 1997; Moezzi, 2000). According to Moezzi (2000), energy conservation focuses on how much energy is consumed while energy efficiency concerns how much energy is used relative to the services demanded. Energy efficiency has historically been closely related and interlinked with economic efficiency (for example the fusing of economic and energy factors in the energy intensity indicator), however the two are distinct concepts[3].

2.4 Origins and development

Despite repeated calls from scholars to analyze energy efficiency in its historical context (Lutzenhiser, 2014; Princen, 2005), there remain few works that have explored the history of energy efficiency exclusively. That being said, however, the historic accounts of both efficiency and energy as separate entities are more extensive and provide an understanding of the origins of energy efficiency and how perceptions of the concept have changed over time. Alexander (2008) and Labanca (2017a) describe how it is likely that the medieval concept of the *efficient* cause was derived from the Aristotelian system of four causes that describe explanations of change or movement. Of them, *efficiens* denotes the active

[3] Economic theory distinguishes between different types of efficiencies, including technical, productive and Pareto efficiencies. Technical efficiency relates quantities of inputs to the quantity of output, requiring the optimum combination of factor inputs to produce a good (Yotopoulos and Lau, 1973). Technical efficiency is also an engineering concept that relates directly with that of energy efficiency regarding the energy input-output ratio. Productive efficiency is related to technical efficiency, where the production of a unit of goods is considered to be economically efficient when that unit of goods is produced at the lowest possible cost (Kopp, 1981). In terms of welfare economics, Pareto efficiency refers to a market outcome that is optimal for society whereby resources are distributed in the most efficient way (Bishop, 1993). Measuring economic efficiency, however, can be subjective when making assumptions on social good or welfare of society and consumers, and Pareto's concept of efficiency does not include issues of fairness or equality among those within an economy (Buchanan, 1959). Furthermore, economic efficiency does not guarantee sustainability (Bishop, 1993).

agent/s that produced change. Sovacool and Dworkin (2015) link energy efficiency to the concept of ethical virtues espoused by the philosophers Plato and Aristotle. In her historical account of efficiency, Alexander (2008) notes that early recorded derivations of efficiency (*efficience, n., efficiency*, n., *efficient*, adj and n., *efficiently*, adv.) were used to describe divine agents and causes of change between the 14th and the 19th Centuries[4]. She explains that between the 18th and 19th Centuries during the industrial revolution and progressive era, efficiency shed much of its religious connotations and adopted instead Enlightenment and Progressive era ideals of human, rather than divine, agency. Social scientists and historians have examined the history of efficiency during the 19th and 20th centuries (Alexander, 2008; Haber, 1964; Hays, 1959; Moezzi, 1998; Princen, 2005; Winner, 1982). These scholars characterize efficiency as a tool linked to the concepts of human powers and abilities to know, reason, plan and build which were allied to ideals of the time: of progress, change, technology and modernity. With the onset of the industrial revolution, as engineers and physicists yielded quantitative metrics to measure the energy and power of machines, they argue, the intellectual core of today's concept of *energy efficiency* was born.

By the late 19th Century 'energy efficiency' was transforming into a formal concept, with its first recorded instance in 1888 in the *Journal of the Society of Telegraph-Engineers and Electricians* (Oxford English Dictionaries, 2018). In its mature technical or mechanical forms, the dominant conceptualizations of efficiency relied on thermodynamic laws describing the inter-convertibility of energy, heat, and motion – known as the thermal 'economy' of a machine (Karns Alexander, 2008). This development came as efficiency widened up to fields as diverse as biology, labour management, economics, and personal discipline in the late 19th and early 20th centuries. Thus, energy efficiency was part of a larger and broader efficiency movement during the progressive era where key figures, including Frederick Winslow Taylor and Harrington Emmerson, linked efficiency to the ideals of objective and credible science and moral virtues including industriousness, inner strength and thrift (Haber, 1964). Similarly, the concept of scientific management gave efficiency a strongly scientific and thus credible connotation. Haber (1964) and Alexander (2008) also point out that once it was formalized, efficiency embodied modernity ideals of unified and testable knowledge based on fundamental, unimpeachable foundation. In this way, Alexander (2008) characterizes efficiency as a technological orthodoxy in that it is a belief system that all things *ought* to act efficiently. She says that like all orthodoxies, it offers comfort and guidance, but it also has the power to harm those who resist conforming to its practices.

[4] From its earliest recorded use in 1398, *efficient* described the action of an operative agent or efficient cause in the processes of production, causation and creation (Oxford English Dictionaries, 2018). In Thomas Spencer's 1628 The Art of Logic the author describes god as the "efficient cause of man" in that god joins form into matter (Spencer, 1628 pp.31).

Historians have illustrated disputes between competing interests including economic, scientific and environmental priorities. Alexander (2008) provides an overview of the conceptual disputes in the late 19th Century, for example, between physicists about the favoured methods of measuring the efficiency of waterwheels. She explains how a conflict emerged between the work of English engineer John Smeaton and the Franklin Institute in Pennsylvania about how to relate the source of a water wheel's motion to the work it produced. While the Franklin Institute argued for a measure of static efficiency, Smeaton aimed for a dynamic measurement, raising a philosophical dilemma about how to measure matter in motion. While Smeaton's experiments led him to consider the theoretical ambiguities inherent in a measure of power or effect, those of the Franklin Institute were designed to sidestep the conceptual ambiguity. In this way, argues Alexander, the dispute raised not only philosophical queries about how to measure efficiency in the material world, but also about who had the right to define the terms of measurement.

In the late 18th century, the first practical and reliable converter of coal into mechanical energy became the next new prime mover successfully introduced after windmills. At the time, there was competition between industrialists to make the most efficient steam engines. To help codify and validate their work on transformations of energy, there was a need to find a formal indicator of thermodynamic efficiency among those constructing thermal engines. These included e.g. Thomas Newcomen and James Watt, who worked on steam engines with the goal to pump more water from deeper coal mines. It was Watt who introduced the first standard unit for power (horsepower), and English physicist James Prescott Joule who helped define the first accurate calculation of the equivalence of work and heat. During the 19th Century, however, the rise of conversion efficiency did not actually result in energy savings. In 1865 English economist Stanley Jevons made the point that the adoption of more efficient steam engines was accompanied by large increases in coal consumption, concluding: "It is wholly a confusion of ideas to suppose that the economical use of fuel is equivalent to a diminished consumption. The very contrary is the truth. As a rule, new modes of economy will lead to an increase of consumption according to a principle recognised in many parallel instances. "(Jevons, 1865 pp.140). While conversion processes have become much more efficient into this present day, the effect that Jevon's mentioned in the 19th century has links to today's debates about the existence of the rebound effect, and other related phenomena (for further discussion, see the next section 'The debate over energy efficiency benefits' pp 36).'

Haber (1964) writes that in 1886, Taylor stated that the different understandings of economic and mechanical efficiencies sometimes created opposing interests. While mechanical efficiency is the output/input ratio of matter or energy, commercial efficiency is the relation between price and cost. Taylor, in comparing the efficiency of two gases in the steel-making process, found that the gas that

yielded the greatest amount of heat per unit did not yield the greatest heat per dollar. Haber notes that the solution to the problem was straightforward: the economic interests of profits prevailed and the mechanically less efficient gas was often used. These dilemmas created a conflict of interests for engineers, who were obliged to ensure economic efficiency on top of their prerogative to design mechanically efficient machines. "This was the situation of the mechanical engineer of this era – he could not feel completely at ease either as a scientist or a businessman", writes Haber (1964 pp. 15).

Haber (1964) also notes the parallels between the popularity of energy efficiency strategies and times of economic crisis and social turbulence. The 'efficiency craze' of the progressive era came amid the financial crises of 1901 and 1907 and public opposition to rate increases of the national railway systems, in particular the Eastern Rate Case of 1910. At this time there was significant momentum for economic reform and efficiency was seen as a win-win solution to solve industrial and social disputes. Scholars have noted that the term energy efficiency in particular became prominent following the 1973 oil crisis amid concerns about energy systems and environmental decline, as well as nuclear risks and costs (Lutzenhiser, 2014). Physicists and environmental advocates used the momentum to point to the needless waste of energy and pollution. Efficiency again became a win-win concept, this time as a sustainable energy solution. Among the influential figures was Amory Block Lovins, who saw energy efficiency as part of a broad and more sustainable 'soft energy path' that integrated energy efficiency, renewable energies, and an equitable social transition rather than the 'hard' pollution-intensive path provided by fossil fuels (Lovins, 1976).

Energy efficiency in the 1970s and 1980s eventually superceded 'conservation' policies that also advocated energy saving (Herring, 2006; Moezzi, 1998). According to Moezzi (1998), in the 1980s U.S. energy policymakers linked energy efficiency with ideals of technological innovation. This was in response to the tarnished image of energy conservation, which had become associated by the mid-1980s with pain and sacrifice together with President Jimmy Carter's notorious phrase 'the moral equivalent of war'. Scholars note that the shift in energy policy towards energy efficiency in the 1980s was tied to the political shift towards economic priorities of free markets and capitalist expansion (Herring, 2006; Moezzi, 1998; Winner, 1982). Owen (1997) describes how a shift in energy policy from energy conservation to efficiency benefited economic agents rather than the national interest in the UK in the 1980s and 1990s. This shift, she argues, was due to a change in regulatory structure that focused less on sustainable development and more on economic competition – by shifting the burden of industry taxes to reduce C02 emissions onto consumers through efficiency policies. Over the past three decades, energy efficiency has become more prominent and institutionalized in regulations, laws, technologies,

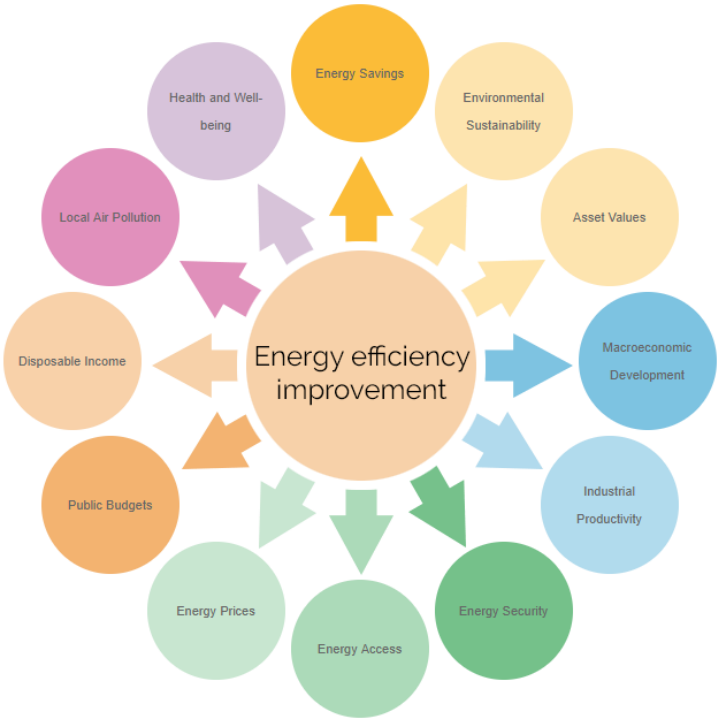
organizations, and professions at all levels (Lutzenhiser, 2014). The policy focus on energy efficiency has risen sharply since the global financial crisis in 2008/09 and increased worries about dependence on foreign energy sources, in particular from Russia following the Crimea crisis of 2014.

The debate over energy efficiency benefits

Among the most recent literature there appears to be a debate among scholars, in particular in the fields of social sciences, economics and engineering, as to the perceived and proven benefits of energy efficiency. According to Gupta & Ivanova (2009), in many cases the deployment of energy efficiency as an energy policy strategy is viewed as non-controversial and desirable. Other scholars, particularly from the social sciences, have critiqued the unquestioned nature of energy efficiency (Herring, 1995; Price, 1995; Princen, 2005; Shove, 2017). Efficiency's popularity as policy strategy can be attributed to the perceived range of benefits that it can provide. These include energy savings, environmental sustainability, industrial productivity and energy security (Cole, McDonald, Wen, & Kramer, 2018; Geller, 2003; Rosenow & Bayer, 2017). Traditionally, energy efficiency has been seen as a strategy to reduce energy use, and, in turn, secure energy supply and encourage better environmental outcomes through reduced inputs (natural resources) and outputs of pollution such as greenhouse gas emissions. Today, many influential institutions including the IEA and World Bank contend that efficiency helps to reduce energy demand growth and creates energy savings (OECD/IEA, 2014; World Bank, 2018). There is also strong policy support for energy efficiency on environmental grounds, for example the European Union considers improvements in energy efficiency as a priority in all decarbonization scenarios presented in the Energy Roadmap 2050 (European Commission, 2013).

There is support in the literature for the argument that energy efficiency fosters equitable outcomes through saving money for consumers, reducing energy poverty (Dernbach, 2007) and its economic benefits, particularly industrial productivity (Boyd & Pang, 2000; Porter & Linde, 1995; Worrell, Laitner, Ruth, & Finman, 2003). As a political tool, it has been acknowledged that energy efficiency is desirable because of its non-controversial nature. "It is a subject, like motherhood and apple pie, on which even the most inept and gauche politician can hardly put a foot wrong" (Price, 1995 pp. 309).

Figure 2. Perceived benefits of energy efficiency improvements



(OECD/IEA, 2014)

However, there are a number of ongoing debates in the literature about the relative utility of energy efficiency and doubt about the evidence supporting perceived benefits. This is particularly the case in the economics field. Firstly, there has long been a debate about the level of energy savings or lowering of energy demand generated through efficient actions, particularly regarding the effect of microeconomic level actions at the macroeconomic level. Concerns regarding a possible reduced level of expected savings from energy efficiency measures were first raised by Jevons (1865). Related concerns were reignited in the 1980s and 1990s amid resource limits and global warming concerns. Key figures included Khazzoom (1980, 1987, 1989) and Brookes (1978, 1979, 1990, 2000) based on the argument that energy price reductions from energy efficiency measures would increase energy demand either directly through price elasticity effects or indirectly through redirected purchases of energy-consumptive goods and services. These concerns were downplayed and critiqued notably by Grubb (1990), Lovins (1988) and Weizsäcker et al. (1997) who argued that energy savings could be achieved through shifting to a services-led economy, technical efficiency improvements and overcoming market barriers.

More recently, there has been an increase in conceptual and empirical work on mechanisms that may reduce expected energy savings through energy efficient actions, commonly known as 'rebound effects' - of which there is still no agreed comprehensive taxonomy (for an overview, see Turner, 2013). The best efforts to conceptualize and define rebound effects often describe (but at not limited to) direct, indirect, economy-wide and transformational rebound effects (Greening et al., 2000; Herring and Sorrell, 2009; van den Bergh, 2011). So far, however, it has been acknowledged that the empirical evidence on the extent of rebound effects is not only inconsistent (Gillingham et al., 2015; Munyon et al., 2018; Sorrell et al., 2009), but inadequate in measuring the full extent of rebound effects across multiple scales, dimensions and taking into consideration system changes (Giampietro and Mayumi, 2018; Hertwich, 2005; Madlener and Turner, 2016). This relates to the view that such phenomena is irreducible to a meaningful quantification based on our current scientific understanding (Ruzzenenti and Wagner, 2018). Therefore, authors have called for more developed theoretical and analytical foundations on rebound and other effects to better inform the literature and ground the empirical work (Madlener and Turner, 2016; Saunders, 2000). In light of this research, authors caution that it would be misleading to equate improved energy efficiency with reduced energy demand (Sorrell, 2015) or consumption (Herring, 2006). Moreover, it is difficult for the results of expenditures into energy efficiency to be monitored, or results to be attributed to energy efficiency measures (Inhaber, 1997; Lopes et al., 2012; Price, 1995).

Regarding the effectiveness of energy efficiency as a climate change mitigation strategy, a dominant view is that energy efficiency is the best low-cost tool to reduce GHG emissions, especially where the economy is not covered by binding carbon reduction targets or a price on carbon (Rosenow, Graichen, & Scheuer, 2018; Sorrell, Mallett, & Nye, 2011). Authors, however, stress that its effectiveness as a climate strategy depends on the methods used and the extent to which energy efficiency is pursued, given diminishing returns to scale (Price, 1995). The IPCC (Bruckner et al., 2014) states that although energy efficiency is an important policy strategy, "a mitigation of GHG emissions in absolute terms is only possible through policies/measures that either reduce the amount of fossil fuel carbon oxidized and/or that capture and permanently remove GHGs from fossil fuel extraction, processing, and use from the atmosphere. The deployment of renewable or nuclear energy or energy efficiency as such does not guarantee that fossil fuels will not be burned (in an unabated manner)" pp. 566-67. Calwell (2010) argues that due to the exponential nature of efficiency ratios (exponential because the numerator increases incrementally by a certain amount for each corresponding increase in the denominator as efficiency increases), while efficiency helps to slow energy and GHG emissions growth rates compared to a business-as-usual scenario, it does not lead to consistently lower absolute energy consumption or greenhouse gas emissions. Patt and colleagues (2018) found that energy efficiency policies could be

counterproductive to climate change mitigation efforts if such policies crowd out or delay a transition to decarbonize the energy supply, or if investments in energy efficiency become more expensive than investments in new renewable energy supply.

Some challenge the equitable outcomes of energy efficiency. This is based on the argument that efficiency actions benefit wealthier consumers and investors rather than the poor on the grounds that efficiency benefits are only available to people who can afford an upfront investment on an individual level (Byrne and Portanger, 2014; Inhaber, 1997; Stein, 2018) due in part to higher discount rates for low-income households (Sutherland, 2003), and that on an organizational level the greatest benefit is enjoyed by owners and investors, rather than employees (Rudin, 1999). Price (1995) argues that efforts to relieve poverty would be better spent by catering directly to the homeless rather than indirectly through energy efficiency policies.

2.5 Untapped potential? How exploitable is the energy efficiency gap?

Despite problems related to proving demonstrated benefits, much of the literature describes energy efficiency as having potential because many of the benefits of energy efficiency strategies are yet to be realized (Jollands and Ellis, 2009; Laitner, 2013). Taking this assumption, a significant body of literature is dedicated to understanding barriers to the 'energy efficiency gap' - the difference between the optimal and actual achievement level of energy efficiency improvement (Hirst and Brown, 1990; Jaffe and Stavins, 1994). This is especially the case regarding industrial energy efficiency where barriers can be classified as economic, behavioural and organizational (Cagno et al., 2013). The concept of gaps/barriers to energy efficiency is both confused and contested due to a lack of consensus on how barriers should be understood, how important they are in different contexts, and how/if they should be addressed (Sorrell et al., 2011). These issues include for example how to deal with overlaps and relationships between barriers, the extent to which barriers influence company decisions (Cagno et al., 2013) and whether market failures are considered absolute or relative (Jaffe & Stavins, 1994). An area that has gained importance since 1980 is that of behavioural science, built on environmental psychology knowledge to include economics, behavioural and social psychology, and technology (Lopes et al., 2012).

A growing area of research addresses the energy efficiency gap from an institutional and organizational perspective. This is especially the case through the lens of energy efficiency governance[5], with scholars taking the view that a more comprehensive governance framework is needed to maximize the potential of energy efficiency efforts (Gupta & Ivanova, 2009; Jollands & Ellis, 2009; Nesbit, 2014). Discussions associated with energy efficiency governance have mainly focused on issues to do with effectiveness, compliance, planning, and reporting, especially in Europe (Pereira and Pereira, 2017).

2.6 Methodological challenges

Measuring energy efficiency itself is complex and challenging. Changes in energy efficiency can be measured in various ways taking into account different energy qualities, scales and dimensions. Energy efficiency indicators can be classified into three main groups, according to Patterson (1996). These include: thermodynamic (the conversion of thermal energy forms into mechanical energy forms -outputs are defined in terms of either heat content or the capacity to perform useful work); Physical-thermodynamic (outputs are defined in physical terms, such as vehicle kilometres or tonnes of steel); Economic-thermodynamic and Economic (outputs and sometimes inputs are defined in economic terms, such as value-added or GDP). Due to its complexity, scholars have acknowledged that energy efficiency is impossible to capture as a whole, and instead a number of indicators are necessary to achieve an approximation of changes in energy efficiency (Phylipsen et al., 1997).

A number of methodological problems have been acknowledged in the engineering and economics disciplines in operationalizing energy efficient indicators (Herring, 2006; Schipper and Haas, 1997; Sorrell, 2015). When taking into consideration both the "inputs of energy" and the "outputs used by society" together, there are various practical problems to be considered when trying to generate a quantitative represention. These include energy quality, boundary, joint production, partitioning and aggregation as well as value judgement problems. Many of these issues emerged during the 1970s regarding debates about Net Energy Analysis - a systematic accounting of energy conversions across the whole energy chain – that ultimately found that such methods were difficult to apply practically given the complexity involved (Giampietro, Mayumi, & Sorman, 2012; Leach, 1975). Even today many of these methodological issues are often misunderstood and are a matter of ongoing debate (Pérez-Lombard et al.,

[5] EE governance is defined by the IEA (2010) as "the combination of legislative frameworks and funding mechanisms, institutional arrangements, and co-ordination mechanisms, which work together to support implementation of energy efficiency strategies, policies and programmes" (pp. 7).

2013). For example, it has been widely acknowledged that the energy: GDP ratio or energy intensity indicator, one of the most commonly used aggregate measures of a nation's energy efficiency, is not an accurate measure of underlying technical energy efficiency[6] (Fiorito, 2013; Freeman et al., 1997; Patterson, 1996; Proskuryakova and Kovalev, 2015; Smil, 2003; Wilson et al., 1994). Instead, the energy intensity indicator tends to reflect other changes such shifts in the sectoral mix in the economy (Jenne & Cattell, 1983), structure of an industry (Freeman et al., 1997) and changes in the energy input mix (Velasco-Fernández et al., 2020). Even measuring energy consumption is problematic due to the complexity in characterizing energy carriers, net available energy, useful energy, purchased energy, all of which measure different outcomes that affect the perception of energy efficiency gains (Phylipsen et al., 1997).

There are also practical problems in the way that energy efficiency improvements are demonstrated, which in turn affect the relative effectiveness of the associated policies to achieve proven energy savings (Schipper and Haas, 1997). For example in Europe, authors acknowledge practical challenges in achieving meaningful measures of energy savings given different methodologies and reference scenarios used by different countries (Economidou and Bertoldi, 2018; Thomas et al., 2012). Furthermore, it can be difficult to demonstrate additionality of energy saved (Economidou et al., 2016) and avoid double counting, free-rider and multiplier effects (Labanca & Bertoldi, 2016; Thomas, Lapillonne, Vreuls, & Labanca, 2009) as well as to gather data effectively (Labanca & Bertoldi, 2016). Due to these challenges, a number of scholars have proposed alternative systems of indicators related to energy efficiency in order to gather, for example, more in-depth and context-specific data (Calwell, 2010; Giampietro & Ripa, 2017; Velasco-Fernández, Giampietro, & Bukkens, 2018) decomposition for sectoral insights (Patterson, 1993) and energy-based performance indicators (May et al., 2015).

2.7 Value judgements – the link between concept and methodology

A major methodological challenge is that efficiency is unable to comprehensively assess the quantitative aspects of massive sets of energy conversions taking place simultaneously, at different scales, and entangled in a series of impredicative relations (chicken-egg paradoxes). Patterson (1996) points out that that while thermodynamic indicators measure the transformation of heat content or work potential into mechanical energy, they do not measure output in terms of practical end-uses. For this to occur, a

[6] Referring to the technological and engineering understanding of energy efficiency of energy conversion processes

methodology needs to be developed to take account of all end energy uses in the economy including e.g. light, sound, mechanical drive, heating, chemical reduction, refrigeration, pumping etc. Sadi Carnot exemplified this point writing that the economy (i.e. efficiency) of the combustion engine should not be the only condition fulfilled by in heat-engines, but should often give precedence to other important considerations including safety, strength, engine durability, physical space and cost (Carnot, 1897 pp 126). In the 1950s ecologist Howard Thomas Odum and others (e.g. Odum & Pinkerton, 1955) advocated for measures of power rather than energy which could, critically, factor in the measure of useful energy per unit of time – a variable which is missing in energy efficiency indicators (Huber and Mills, 2005). For example, a car's movement that is calculated as gasoline consumed per km may not include any data about the duration of the trip (the power at which the mechanical power is generated). However, the most efficient car would likely be that which can only travel 1 km/hour, which is not useful in terms of end uses for the society. From a technical point of view, the inability of a specific quantitative assessment of energy efficiency to measure other relevant variables for assessing the performance of the conversion can become problematic and masks the effect of what is really being measured, and what is not. This problem can be explained by the fact that originally, during the industrial revolution, energy efficiency was a concept used to analyse the performance of a specific observable processes (having clear boundaries in space and time) producing an output (machine power generating mechanical energy) while using an input (an input of energy fuel, thermal energy) In this situation, energy efficiency is comparatively straightforward to measure, as the inputs and the outputs are measured in comparable energy forms. This conceptualisation can be distinguished from later conceptualisations where the definition of energy efficiency in time became more complex, and the 'output' of the input/output energy efficiency ratio became a subjective value in that it was no longer an easily measured energy unit.

This challenge relates to the methodological conundrum regarding value judgements inherent in measures. Specifically, scholars have noted the problematic ambiguity of the term 'output' due to the fact it can mean various things depending on the context with which it is used (Boulding, 1981; Patterson, 1996; Princen, 2005; Shove, 2017). Today, the output is often expressed as 'useful output' or 'energy services' that a given input delivers such as heating, cooling or transport. Patterson (1996) and Pérez-Lombard et al. (2013) point out that the term 'useful output' implies the need to assign human values and value judgements in order to define what is considered to be useful. Similarly, 'energy service' is difficult to measure and is subjective and dependent upon social context (Sorrell, 2015). For example, Boulding (1981) states that despite the significant increase in overall energy consumption that coincided with the growth of the burgeoning electric power industry between 1910 and 1950 in the U.S., official statistics showed a sharp increase in the total energy efficiency of the economy, as measured in real GNP per unit

of energy input. Here, Boulding explains that in technical terms, electricity generation, as an output, is considered a relatively inefficient process, given the level of fuel input required for conversion. Rather, he points to the fact that the choice of output (electricity) is a value judgement for high levels of energy services rather than a truly efficient use of energy.

Princen (2005) and Calwell (2010) find the nature of energy efficiency problematic in its numerical representation.These authors argue that the nature of rising consumption patterns are masked when improvements in energy efficiency over time are expressed as a sequence of simplified ratios[7], whereby the numerator increases incrementally by a certain amount for each corresponding increase in the denominator. They argue that useful and meaningful information such as energy quality, environmental damage etc is lost in the ratio format.

The issue of value judgements is addressed separately in sociological research in addition to the discussions found in the technical engineering and economics literature. Taking a social practices theory perspective, Shove (2017) argues that the ambiguity inherent in the output of energy efficiency ratios (energy services), reproduces and stabilizes unsustainable concepts of service. The pursuit of energy efficiency is "counterproductive", she argues, because energy efficient strategies reproduce specific understandings of the way we live ('service') which justify high living standards that are determined by culture and norms. This echoes calls by other scholars who argue that energy efficiency strategies are unsustainable long term because they tend to sustain and reinforce a certain (often stable) level of product service or performance which does not guarantee energy savings (Calwell, 2010; Herring, 2006; Rudin, 2004).

2.8 Sociological Perspectives

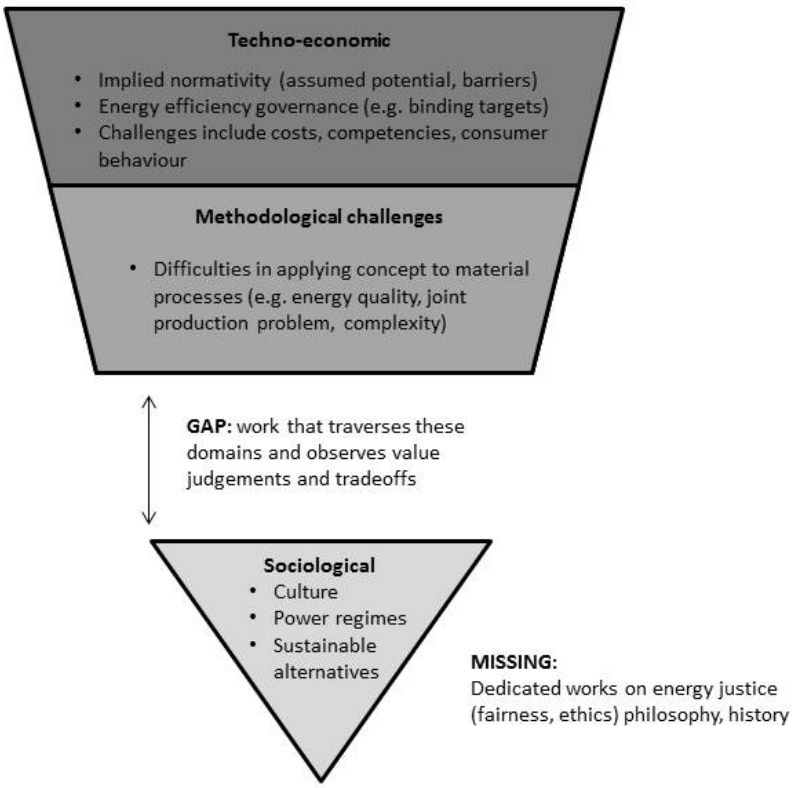
There has been a deficit of social sciences literature examining energy efficiency since the 1970s (Lutzenhiser, 2014). Despite this, however, some notable examples have explored energy efficiency through the lenses of ethical, social justice and environmental concerns (e.g. Calwell, 2010; Herring, 2006; Moezzi, 1998; Princen, 2005; Shove, 2017; Winner, 1982). Herring (2006 pp. 19) states: "The key questions [regarding energy efficiency] are ethical, not technical, cultural, rather than economic". In particular, social scientists have pointed to the narrow vision of energy efficiency and its lack of attention

[7] Common efficiency ratios include lumens/watt (lighting), liters/100 km or miles per gallon (vehicles), CFM (cubic feet per minute)/watt (fans), and watts/square foot or kWh/square meter (buildings)

to alternative and less energy-demanding solutions to environmental, social and economic sustainability concerns. For example, authors claim that energy efficiency can mask negative externalities particularly for environmental and justice/equity considerations (Byrne and Portanger, 2014; Princen, 2005).

Scholars from social practices theory have questioned why energy efficiency actions focus more on what they see as overly-simplistic techno-economic approaches to reduce energy consumption, rather than observing more complex social contexts and practices to find solutions. "Why is it that some technologies (insulation, heating systems) figure so prominently in evaluations of efficiency while others, including clothing, chairs, carpets, slippers and curtains, do not?", queries Shove (2017). Similarly, Labanca & Bertoldi (2018) call for more qualitative

Figure 3. Conceptual diagram of energy efficiency literature



measures arguing that the central question should be whether efficiency policies do *better* with less energy, not necessarily that they do *more* with less. These authors critique dominant policy prerogatives to reduce energy with quantitative and technical fixes that assume the existence of basic cause-effect relationships between given exogenous factors (e.g. provision of information, price signals) and individual behaviours. This view builds on earlier works focusing on the sociological blind spots in energy (Shove and Walker, 2014; Wilhite et al., 2000) and climate policy (Shove, 2010). Social scientists have recommended other alternatives to energy efficiency that build on the earlier ideas of 'conservation ethics' pioneered by authors including Leopold (1949) and others in the realm of efficiency strategies (Sachs, 1988). These include the concept of 'sufficiency' where the focus is more on living better with less resources (Carley and Spapens, 1998; Thomas et al., 2015; Trainer, 1995), or eco-efficiency, focused on absolute, rather than relative, assessments of performance towards sustainable industrial practices (Hauschild, 2015).

Some have focused on the institutional context of energy efficiency from a political economy perspective. Winner (1982) critiques the narrow scope of the energy efficiency agenda that takes place within a framework of economic growth. He argues that more focus should be placed on the social and political dimensions of energy system structures, including highly coordinated institutional arrangements, or 'regimes' (e.g. activities of work, management, finance, planning, marketing) together with the sociotechnical systems that link production, distribution, and consumption in coherent patterns. This, he states, is important to understand asymmetrical power distribution and how energy regimes affect the structure and texture of human life. Demonstrating that the same challenges exist today as they did four decades ago, Lutzenhiser (2014) scrutinizes what he calls the 'Energy Efficiency Industry' (EEI), referring to the coordinated actions of institutions such as utility companies, government agencies, business firms, and non-profit advocacy groups involved in the process of producing energy efficiency as an output. He argues that the EEI is guided by a narrow economic conceptual frame that is inhospitable to the social sciences, and limits efforts for climate action. Lutzenhiser (2014) writes that energy efficiency institutions and values have been shaped by the broader cultural movements and context of which they are a part, e.g. ideals of modernity and technocratic principles. He says that these practices in turn are legitimized through institutional frameworks and their goals of rational reductions in energy use, for example through units of GDP, business output, government services, personal wealth and utility.

Although the concept of energy justice has been widely covered since its inception over a decade ago in energy literature (See for example Heffron & McCauley, (2017); LaBelle, (2017); Sovacool & Dworkin, (2014); Sovacool, Heffron, McCauley, & Goldthau, (2016)), there is very little research dedicated

exclusively to the issue of justice in energy efficiency (Byrne and Portanger, 2014). Sari and colleagues (2017) argue that the mainstream economic approach of energy efficiency reflects an underlying Coasean perspective (Coase, 1960) in that issues regarding efficiency can be separated from the issue of equity[8]. Thus, the authors argue, the dominant framework in energy economics and energy policy arises from a utilitarian (maximum efficiency) approach that is not concerned with how rights of the public good/bad are assigned as long as an efficiency outcome is reached. Taking this environmental justice argument further, scholars assert that issues of efficiency and distribution should not be separated given instances of inequalities and injustices that occur within these paradigms (Lohmann, 2010; Martínez-Alier, 2008).

While there has been little philosophical work done specifically on the topic of energy efficiency, some authors have discussed ontological issues related to efficiency more generally. For example, Sari et al. (2017) discuss how efficiency outcomes depend on how one defines 'benefit' and 'cost'. Hence, these authors emphasize the need to understand political processes related to energy efficiency targets including how and by whom the target is set, and how the means to achieve the target are set up. According to Alexander (2008) and Kuennen (1994), efficiency is an ambiguous and highly contextual concept. As such, it has an instrumental, rather than intrinsic value: "By definition, the efficiency of an action is dependent on the evolving or developing material and ideological context in which the action takes place. According to these authors, this ambiguity makes efficiency a difficult concept to study, because the worth and value of an efficient action is dependent on the context in which it is used. This ambiguity raises ethical questions related to veiled contextual information (Herring, 2006; Rudin, 2004) which are often overlooked, especially when efficiency is not properly unpacked, or the definition remains obscure or omitted. By emphasizing the context in which efficiency is applied and used, however, scholars have been able to address complicated issues of moral value that often surround efficiency "chief among them its use in the service of inhumane or immoral ends" (Alexander, 2008 pp.4).

Taking the issue of ambiguity further, the philosophical efficiency literature points out that efficient actions can be seen as either a means to an ends, or as an ends to a means - or both. In other words, efficiency can be both a method of quantification and also the end goal of efficient actions: "It appears to be merely a technique of quantification, yet it also appears as the goal toward which quantification is employed. It can be both the model of a well-controlled process and a tool to help achieve that control"

[8] The Coase theorem states that competitive markets bring about an efficient allocation of resources regardless of the distribution of property rights (in the absence of transaction costs). It states that if there is a conflict of property rights, a negotiation between parties is more efficient than one derived by assigning property rights beforehand. In this way, the theorem separates the issues of efficiency and equity.

(Alexander, 2008 pp. 4). For these reasons, some authors argue that efficiency in itself should not be the end goal, but simply a means (Kuennen, 1994; Princen, 2005). Lovins stresses that the 'soft energy path' assumes that energy is but a means to social ends, and is not an end in itself (Lovins, 1976). Kuennen (1994) argues that by conceptualizing efficiency as an end in itself is problematic in that humanity and nature are reduced to narrowly defined efficiency equations, leaving them subject to unwanted social and environmental consequences. In this way, he views efficiency as a dividing force that drives a wedge between segments of humanity, and between humanity and nature. This view relates to Shove's (2017) analysis which explains that concepts and measurements of energy efficiency have become detached and abstracted from the physical situations in which energy is used and transformed. By focusing on only specific and technical aspects of energy performance, she says, programmes and policies of energy efficiency necessarily miss what matters, which is focusing on stemming long-term energy consumption trends. Ruzzenenti & Wagner, (2018) view energy efficiency as a legitimizing device for high energy consumption levels that shifts the tension between the imperative of economic progress and the constraints imposed by resources depletion from the present into the future. In doing so, the authors argue, energy efficiency distracts attention away from our current responsibility to reduce unsustainable energy use, such as through renewables or through a 'steady-state' economy, as opposed to the current economic growth paradigm.

2.9 Gaps and way forward

By observing how energy efficiency is conceptualized, this review has revealed the varied epistemologies, ontologies and methodologies addressed in the literature – and also where gaps exist. Firstly, the review illustrates the limited number of historical works dedicated exclusively to energy efficiency. Those that did covered only specific snapshots in time, namely that of the progressive era or during the oil crises of the 1970s. This omission comes despite the perceived importance in the literature in analyzing debates over quantification in their historical context (Asdal, 2008; Porter, 1995; Serres & Latour, 1995) so as to observe similar cases of political and moral decision-making and how events of the past fold themselves into the present. It is clear that the concept of energy efficiency itself has a rich history steeped in various meaning and values, much of which has not been explored. Thus, the questions: 'how did the concept of energy efficiency emerge and why?', and 'how has the concept changed over time?' still have not been comprehensively answered.

In terms of contemporary conceptual literature, the review reveals a dominant line of research that aims to understand the benefits of energy efficiency, and how the full potential of energy efficiency can be realized. This literature stream is largely geared towards technical and economic perspectives. This body can be characterized as having a normative view in assuming that energy efficiency is an inherent good and therefore a preferred strategy to achieve multiple benefits. When reviewing this literature guided by the research questions 'what are the benefits of energy efficiency, and how can they be proven' and 'what are the counterpoints to these benefits', it is clear that concepts of benefits and gaps are confused and contested across different fields and institutional contexts. This lack of consensus could be due to the fact that the additionality of energy efficiency benefits, including reduced energy consumption, reduced emissions and reducing energy poverty, are difficult to demonstrate empirically. This conundrum begs the further question: if we cannot demonstrate benefits with certainty using current scientific methods, what methods do we need to employ to tackle this uncertainty?

Complexity is also a major theme evident in the methodological literature. This body of research, represented mainly by the engineering, systems science and economics fields, reveals the technical challenges in employing a given methodology and why different methodologies exist. What is missing in this technical research is attention to sociological aspects and tradeoffs inherent in measures, for example, sustainability and equity/justice concerns. There are, however, a small number of studies that endeavour to fill this gap by combining technical methodological literature with the more qualitative sociological aspects, but these are largely confined to either the broader efficiency (Karns Alexander, 2008; Princen, 2005) or energy literature (Giampietro et al., 2017). Of the literature that does traverse these terrains, however, a key overlap was observed: value judgements in measures. Value judgements, for example, are characterized as the 'output' in efficiency ratios by various authors. Thus, the research question 'how are value judgements manifest in energy efficiency measurements?' provides a fruitful unexplored area for further research. Such multidisciplinary research that can connect the technical and sociological fields of energy efficiency is sorely needed because a technical analysis is required to understand how indicators, through their construction and application, can render social, ethical and environmental issues invisible. For example, analyses that focus on the societal effects of contemporary measurement and quantification methods would be highly informative. Such points of research could include, for example, the definition of primary energy which often does not include externalizations such as pollution displacement, how the Primary Energy Factor (PEF) is calculated which can benefit certain actors and energy technologies over others, and how the burden of energy efficiency measurements at different points along the energy chain privileges certain actors over others.

Finally, the sociological literature that observes energy efficiency concepts exclusively is scarce. In particular, attempts to answer the research question 'what sociological and environmental aspects does energy efficiency miss?' are significantly underrepresented. Of the few works found that do address these concerns, a number of themes can be identified. In many cases authors describe the narrow economics focus of the energy efficiency concept that can obfuscate wider societal issues – specifically those concerning energy justice, environmental and philosophical concerns. Of this literature, more studies tend to observe energy efficiency on a micro-level scale, for example household-level efficiency actions (Moezzi, 1998; Shove, 2017), rather than on the more complex macroeconomic scale where there exist many methodological and policy challenges regarding complexity, uncertainty and measurement (Labanca, 2017b; Ruzzenenti and Bertoldi, 2017).

Another remaining gap identified by Winner (1982) over three decades ago and reiterated by Lutzenhiser (2014) is the lack of analysis of the political and institutional contexts within which concepts of energy efficiency are produced and performed. This comes despite notable work on issues to do with agency and structure and the interplay of power in the wider field of energy (e.g. Stirling, 2014) and studies that investigate how nature and natural resources are quantified, classified, unified and linked to political and economic processes and structures (e.g. Asdal, 2008; Turnhout et al., 2007). Regarding efficiency networks then, it is important to look at the institutional and organizational context, materialities and techniques of energy efficiency institutions to understand how this power is manifest (Lutzenhiser, 2014) and how processes of quantification involve ongoing social and political negotiations over who has authority to measure what and by what standard (Alexander, 2008; Porter, 1995). This is in order to better understand how processes of quantification and classification are woven together with issues to do with trust, truth, expertise, power and control (Foucault, 1980; Haber, 1964; Porter, 1995; Scott, 1998).

2.10 Summary

A question seldom asked is: why is energy efficiency important? Is it because energy efficiency is assumed to have intrinsic value and therefore not worth further conceptual investigation? Delving into the expansive energy efficiency literature it is clear that the concept of energy efficiency is ontologically ambiguous. Therefore, as its meaning changes depending on context, so does its perceived utility vary depending on who is using it, where, and how. Firstly, this review shows that investigations into the historical and cultural underpinnings of energy efficiency remain scarce. Of the more recent literature, a dominant view tends to assume that challenges encountered in its application are caused by certain

economic, behavioural or institutional 'barriers' rather than conceptual, political or cultural aspects. Challenging this dominant normative view, the full snapshot of diverse perspectives in this review illustrates that the benefits of energy efficiency are difficult to demonstrate empirically within complex systems, and therefore new methodologies and perspectives are needed to tackle social and environmental challenges embedded in a transitioning energy system. A methodological body of knowledge reveals the significant challenges in applying the concept of energy efficiency to the material world, including the epistemological conundrum of value judgements. Here, a rich area for future research exists at the nexus between the technical methodological and social sciences knowledge. This type of multidisciplinary research is critical to understand the underlying practices, relationships and institutional politics being performed within complex social-ecological systems, and the tradeoffs of energy efficiency actions. While some notable research has explored the wider sociological and cultural aspects of energy efficiency, this area is a no-man's land compared with other fields including economics, engineering and information technology. By presenting a diversity of views on energy efficiency, this review highlights the need for transversal research that can provide a more nuanced and fuller picture of energy efficiency to address pressing social and environmental challenges and solutions going forward.

Chapter 3 – The evolution of a 'Motherhood' issue

3.1 Introduction

In broad terms, energy efficiency is a straightforward concept – to use less energy for the same level of output. As we saw in Chapter 2, however, it proves to be a complex idea, imbued with multiple meanings (Dunlop, 2019). The complexity in the definition of energy efficiency stems from its ambiguity. The review revealed that a key methodological challenge in energy efficiency is to determine what a 'useful' output is (Patterson, 1996), because 'useful' is subjective and thus contains built-in value judgements. As Boulding (1981 pp. 153) writes, "The significance of the efficiency concept … depends on the significance of the outputs and inputs in terms of human valuations. This problem affects evaluations of efficiency more broadly. Wildavsky (2018) observes that efficiency "does not tell you where to go, but only that you should arrive there (or go part of the way) with the least effort". Stone (2012) defines efficiency as 'getting the most for the least, or achieving an objective for the lowest cost' (Stone, 2012). Due to its lack of concrete values, she does not see efficiency as a goal in and of itself, but as a means to achieve different goals. The analysis here applies Stone's (2012) approach to efficiency more generally to energy efficiency, using in particular the concept of 'motherhood issues' to understand the underlying values inherent in the conceptualization of energy efficiency in EU policy. Stone's discursive approach falls under the umbrella of 'post-positivist policy analysis', which treats policymaking as a dynamic space where ideas and values are constantly contested. More specifically, the 'argumentative turn' (Fischer and Forester, 1993; Majone, 1992) puts language and argumentation at the centre of the policy process. As Hajer and Versteeg (2005) state: "Language profoundly shapes one's view of the world and reality, instead of being only a neutral medium mirroring it" (pp. 176). Drawing on Foucault, Dryzek (2013 pp. 9) sees discourse as 'a shared way of apprehending the world'. Here, policy language is analysed to understand the critical issues of truth and power in the construction of causality, legitimacy and responsibility, interests, needs, values, preferences and obligations.

Energy efficiency as a motherhood issue

Stone (2012) contends that policymaking is a constant discursive struggle over problem definitions, societal classification, category boundaries and the definition of ideas, which guide how people behave. The conceptual framings of problems and goals determine ideas about how these problems should be

solved and whose responsibility it is to solve them. Stone's policy analysis recognizes the complex and ambiguous nature of policy making due to the multiple values and perspectives involved in the process. This involves taking stock of analytical concepts, problem definitions and policy instruments as political claims in themselves, rather than just granting them privileged status as universal truths. Policymaking involves disputes over 'motherhood issues' – enduring values of community life that are the standards of analysis most commonly invoked in policy debates, such as equity, efficiency, welfare, liberty and security. While generally supported by everyone in the abstract, these motherhood issues often lead to contradictory interpretations when concretized. 'Behind every policy issue lurks a contest over conflicting, though equally plausible, conceptions of the same abstract goal or value' (Stone, 2012 pp. 14). Therefore, ideals often conflict in policy implementation, necessitating compromise. One task of the political analyst is then to clarify the underlying value disputes to see where they differ, so that differing parties are able to move towards some reconciliation.

To avoid the paradoxical trap of the 'rationality project', rendering policy apolitical through the application of rational, managed and simplified analytical methods, Stone proposes a mode of policy analysis that recognizes the complex, messy and ambiguous nature of policy due to the multiple values and perspectives involved. This involves taking stock of analytical concepts, problem definitions and policy instruments as political claims in themselves, instead of granting them privileged status as universal truths. In particular, she highlights the importance of analyzing the complexity of problem definition to understand the multiple conceptions of the given motherhood issue. Therefore, politics should be viewed as a way for people to help each other see from different perspectives – a desirable process that can allow society to avoid myopia and help solve common problems more effectively. In this process, values matter – and policy analysts and decision makers must bring their own values into the picture. To understand the underlying values in efficiency policy generally, Stone identifies three main areas of contention that should be highlighted: Who gets the benefits and bears the burdens of a policy? How should we measure the benefits and costs of a policy? And what mode of organizing human activity is likely to yield the most effective results?

This article approaches energy efficiency as co-constructed in that the conceptualization of energy efficiency depends on various actors, institutional logics and discourses about its use and implementation. It represents a solution that depends on the specific creation of multiple problem definitions. Meanings are created, argued and won through language and discourse in politics, and some potentially relevant concepts get sidelined in favour of others. I apply this frame to understand how energy efficiency is used as a rhetorical device in EU policy and to see the sociological and environmental problems embedded

within seemingly neutral technical definitions and measures. I apply Stone's discursive toolbox to EU energy policy documents over seven decades and using insights from her theories to analyse who benefits, how costs and benefits are measured and policy effectiveness of energy efficiency policy. Building upon these discursive insights, I explore how the concept of energy efficiency can be broadened to take into consideration sociological and environmental issues.

3.2 Methods

The study looked at the EU because energy efficiency has been a significant focus for the European bloc over time and the EU encapsulates perspectives from various countries. Twenty policy documents were selected based on their relevance to energy efficiency policy, chosen to provide a comprehensive overview of policy between the 1950s and 2018. Although these documents were representative of the main themes that emerged in each decade, other documents (grey literature and scientific articles) were also assessed. The 1950s were selected as a start date to observe the characterization of energy efficiency in the post-war years before it took on a narrower meaning, and to see when, how and why energy efficiency became prominent in policy. A minimum of two documents were chosen from each decade, with criteria used to determine their relevance to policy based on the breadth and depth of their treatment of energy efficiency. This included the ways in which documents referred to energy efficiency, such as providing context, detail for planned actions and justification for actions taken. To ensure comparability, balance and comprehensiveness of information, the documents analyzed included mainly EU directives provided by the Council of the European Union and 'Communications' written from the European Commission to the Council[9]. Given that the EU has changed over time as an institution, documents were selected from earlier manifestations that included the Commission of the European Communities, European Coal and Steel Community, and European Atomic Energy Community.

An analytical framework of four code elements based on Stone's (2013) discursive methodologies was developed: (1) symbols, or verbal languages, (2) numbers, numerical languages, (3) interests, and which actors are involved on different sides of a debate, and (4) facts, or information used to persuade. These codes were applied to the documents in three iterations of increasingly fine-grained analysis. The codes were analysed, taking into consideration theoretical questions concerning efficiency as a motherhood

[9] However, in the earlier decades (1950s and 1960s), neither the directives nor communications dedicated to energy policy mention energy efficiency or efficiency in any detail. Therefore, strategic energy planning documents from these decades were analyzed to gain insight into the treatment of energy efficiency topics in those decades.

issue: Who gets the benefits and bears the burdens of a policy? How should we measure the benefits and costs of a policy? What mode of organizing human activity is likely to yield the most effective results? The codes were then used to synthesize the discourse analysis below. It should be noted that the analysis is not intended as a comprehensive study of energy efficiency indicators and measures, but rather as a broad synthesis of conceptualizations of energy efficiency over time.

3.3 Analysis of discourse of energy efficiency in EU politics

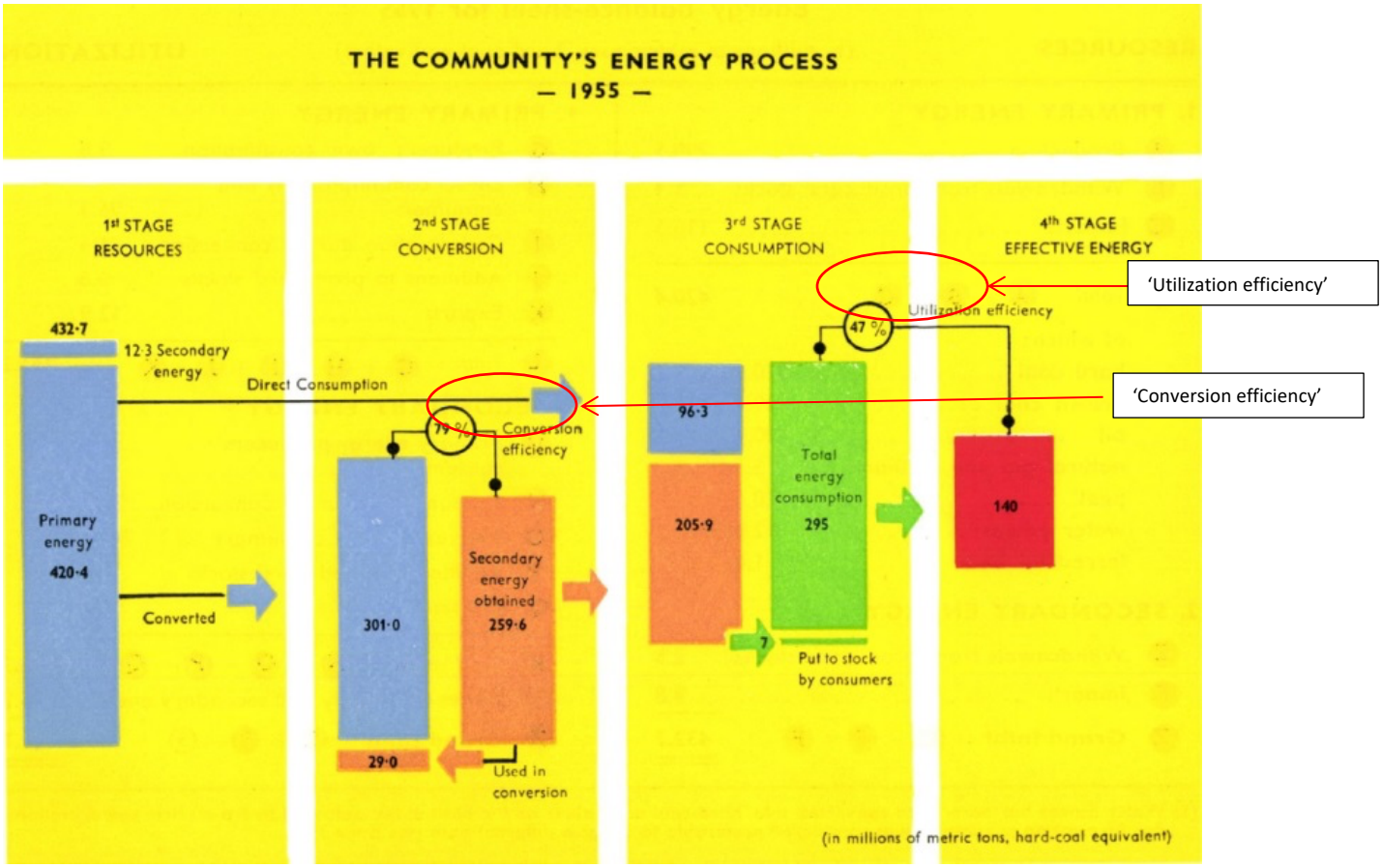
Discourse analysis across seven decades of energy efficiency policy documents in the EU illustrates significant variations in the concept of energy efficiency over time, including how it is defined and measured. The meaning of energy efficiency gradually becomes broader, more detailed and complex, as new concepts are attached to the term. While the quantitative characterization of energy efficiency as a ratio remains constant, the qualities and characteristics of the outputs in the equations change (such as, for example, the substitute of energy output for gross domestic product or energy services). Another constant across the decades is that energy efficiency policy generally favours economic interests over social or environmental ones. This is revealed through language and in concrete policy actions. Below is a breakdown of the concept as it is defined and characterized in different eras.

The nuclear era

Beginning in the 1950s, the documents describe concerns about limited natural resources, especially oil imports to Europe, following the 1956 Suez crisis, which disrupted the major shipping route through the Suez Canal, severely disrupting oil exports to Europe. In the 1960s, the threat is characterized as a coal industry in decline and over-dependence on energy imports. During these decades, nuclear energy is presented largely as the solution to energy supply problems. Efficiency in relation to energy is mentioned very little in the documents of the 1950s and 1960s. When efficiency is mentioned, it describes energy conversion processes in fairly simple terms that involve only energy inputs and outputs. In 1958, for example, 'efficiency' is described as 'conversion efficiency' (the ratio of the secondary energy obtained to the primary energy used to obtain it') or 'utilization efficiency' ('the ratio of effective energy obtained to total energy consumed') (European Coal and Steel Community, 1958 pp. 9). Primary energy is the total energy consumed, i.e. the energy that is extracted from the earth as either oil, sun, wind, gas or coal. Secondary energy is the energy consumed at the consumer end. In between these two stages, the energy is

converted, which involves a loss of energy. This conversion is called 'conversion processes'. A 1950s document states the importance of being mindful about the use of limited natural resources, such as coal, oil, gas and peat. However, price concerns are seen to have a greater importance: 'It is uncertain how low this "natural capital" will last. But still a more important point is how long it will be possible to go on securing energy supplies at present costs' (European Coal and Steel Community, 1958 pp. 6). Paradoxically, however, the same text does not state that atomic energy has any supply limits: 'A growing population can only be assured of a high and rising standard of living if the quantities of energy available go on increasing' (pp. 5). Looking at interests, the main actors referred to include industry: coal plants, thermal power stations and transport sector. The texts of the 1950s refer to the human population as an aggregate entity, i.e. 'the population' or 'end-consumers'. There is no mention of experts or scientists, although predictions are made about future energy demand without stipulating how the figures were calculated and who calculated them.

Figure 1: 'The Community's Energy Process 1955' (Taken from A problem for Europe: The Supply of Energy (European Coal and Steel Community, 1958))**.** *Here four stages of energy processes can be observed:*



Oil crises

The 1970s are characterized by concerns about energy supplies in the wake of oil crises and high energy prices are said to threaten the standard of living and cohesion of the [EU] Community. Energy efficiency and nuclear energy are mentioned rarely. Instead, the main focus is on the 'rational' use of energy to avoid energy wastage: 'The Commission has been examining the question of using energy in a more rational manner since the end of 1971, by which time it had become apparent that raw materials (including certain energy resources) were in short supply and often used wastefully' (Council of the European Union, 1974 pp. 4). Here, efficiency is characterized as a tactic to achieve a 'rational use of energy', which falls under the umbrella of 'energy conservation' more broadly. The aim of energy conservation in this context is to reduce energy use and achieve energy savings. Energy savings are measured according to an indicator of energy consumption. Efficiency is generally mentioned together with technical conversion processes, e.g. efficiency of combustion, heat, lighting and power. In other cases, it is referred to vaguely, as an adjective ('efficiently') rather than as a noun ('energy efficiency') to describe less wasteful energy processes: 'There are many techniques which could be employed in order to use energy more efficiently; the constraining factor is their economic viability' (Council of the European Union, 1974 pp. 6). Definitions at this time make clear that energy efficiency actions do not involve a reduction in energy output or comfort. A 1974 text explains that both energy efficiency and the reduction of consumption of non-useful energy aim 'solely to reduce energy input while providing the consumer with the same level of output'. (Commission of the European Communities, 1974, pp. 5). This is in contrast to a 'demand restraint of useful energy' which involves a 'sacrifice on [the] consumer's part' (p.5). This sentiment is repeated in 2003: 'Without reducing comfort or standards of living, it is therefore possible to reduce energy consumption by at least one-fifth at no extra net cost – and in many cases negative costs' (Commission of the European Communities, 2003).

Figure 2: Conceptualization of Energy Conservation (Annex 1 in "A Community Action Programme and Draft Council Resolution on the Rational Utilization of Energy") (Commission of the European Communities, 1974)**:**

Figure 2 displays the concept of energy conservation. In this schema, the objective of the "rational use of energy" falls under the umbrella of energy conservation more broadly, and energy efficiency is seen as a tactic to achieve the rational use of energy.

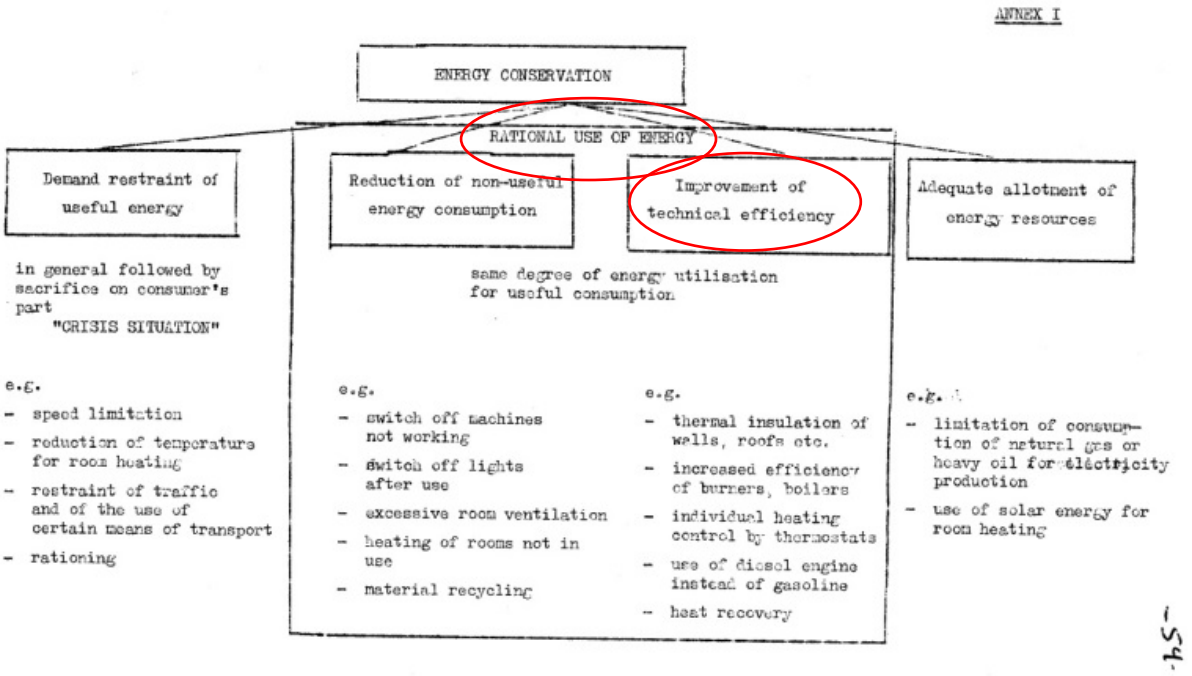


Figure 2 also illustrates the fact that energy efficiency actions tend not to involve a reduction in output or comfort. In its characterization of energy conservation, the text stipulates that both energy efficiency and energy the reduction of consumption of non-useful energy, aim "solely to reduce energy input while providing the consumer with the same level of output". (Commission of the European Communities, 1974 pp.5), while contrasting these with the measure of 'demand restraint of useful energy' which involves a *"sacrifice on [the] consumer's part" (see Figure 2).*

The actors mentioned during the 1970s are limited generally to the Administrative Authority (Commission of European Communities and Council) and experts and specialists who are mentioned as authority figures tasked with conducting assessments and solving problems. Experts and managers take prominence in the text as problem solvers. For example, national experts from the Energy Committee's Working Party on the rational use of energy helped to formulate the action programme. These specialists

are also to be called upon to 'organize an information drive for the general public' (Commission of the European Communities, 1974 pp. 10).

Market rationalization

Following a global economic recession in the early 1980s, the problems in this decade are seen to be energy price increases, and the dependence of European countries on oil. Correspondingly, the documents show an increase in the use of economic and financial terms and concepts, linking them to energy efficiency. For example, the terms 'competition', 'prices' and 'costs' are used frequently, and 'the market' emerges in relation to energy efficiency and the rational use of energy. For example: 'It is particularly important from the point of view of the rational use of energy that energy be priced with due regard for the market and costs' (Council of the European Communities, 1985: pp. 2). Energy efficiency is still seen as a tactic to achieve energy savings and a rational use of energy. However, mentions of the 'rational' use of energy and energy conservation decrease markedly, while mentions of energy efficiency increase. For example: 'Efficient use of energy: This will be by far the most important factor influencing future energy consumption' (Commission of the European Communities, 1985 pp. 17). As it appears to decline in importance, the rational use of energy is referred to in a less defined and vague way, aligned with the virtue of prudence: 'This Directive aims to preserve the quality of the environment and to ensure a prudent and rational utilization of natural resources' (Council of the European Communities, 1993 pp. 1). At times, the rational use of energy and energy efficiency are described together as if they were the same: 'The increase in energy intensity during recent years and the reduced support for rational use of energy are symptomatic of the danger of complacency in energy efficiency during a period of stagnating or falling fossil fuel prices' (Commission of the European Communities, 1987 pp. 4).

The quantitative representation of energy efficiency in the 1980s adopts a new economic dimension with the energy intensity indicator, i.e., units of energy per gross domestic product (GDP). In 1985, the document discusses the challenges of using various energy intensity indicators, which include the ratio between final energy demand and GDP as well as primary energy and GDP: 'Neither of these measures provides a perfect basis for analysis of increased efficiency, since both can be influenced by changes in the structure of GDP' (Commission of the European Communities, 1985 pp. 25). The text explains that the indicator of ratio of final energy demand to GDP is chosen in order to keep measures simple, and because 'the relationship between GDP and primary energy demand can be distorted by the rate of electricity penetration and the structure of electricity supply' (Commission of the European Communities, 1985 pp. 25). Correspondingly, in 1986, the Council adopts a resolution for a 20% improvement in

energy intensity of final demand by 1995. Here, 'benefits' in relation to energy efficiency are mentioned for the first time: 'Energy efficiency measures will also create new jobs and industrial activity and support environmental aims' (Commission of the European Communities, 1985 pp. 17).

The variety of different actors mentioned in the documents increases in this decade. There is less mention of undefined experts, and more of concrete industry figures, such as energy managers, savings advisors and consultants, as well as public institutions such as schools and universities. The 'public' is still referred to as an aggregate entity to be acted upon. For example, under the heading 'Measures to encourage the rational use of energy', the text states: 'Information programmes with a view to stimulating further public awareness on the efficient use of energy by advertising campaigns' (Council of the European Communities, 1985 pp. 2).

Environmental Awareness

The environment becomes a concern in the mid-1980s, when texts mention problems with pollution, such as from car exhaust fumes. Global warming is stated as a major problem in the 1990s and energy efficiency is linked to the reduction of carbon emissions. Energy efficiency becomes the main subject of legislative proposals for the first time in 1991, when the Council announces the 'SAVE' (Specific Actions for Vigorous Energy Efficiency) 5-year programme. Thus, at this time, energy efficiency has gained more prominence with energy conservation and the rational use of energy only mentioned in reference to past policies. In 1993, energy efficiency is characterized as a means to achieve emissions reduction in the directive to 'limit carbon dioxide emissions by improving energy efficiency' (Council of the European Communities, 1993). The problem of global warming evolves into 'climate change' in the 2000s and 2010s. While these texts appear to focus on environmental concerns, evidence suggests that economic aspects are the main priority. In 1998, for example, the environment is mentioned as the most important issue, though very little detail regarding environmental objectives and actions is listed. The priority is 'to underline the economic potential for energy efficiency' (Commission of the European Communities, 1998: pp. 1). In 1995, a 12% improvement in energy intensity of final consumption was achieved, falling 8% short from the 20% target. In 1998, a specific target was set to improve energy intensity of final consumption by an additional one percentage point per annum up to the year 2010.
Energy efficiency and technology are described as a 'balanced approach' solution to diffuse and harmonize conflicts between the opposing interests of the energy industry (growth, industry) and environmental interests (reducing greenhouse gas emissions). Hence, one major objective is described as:

'The balanced pursuit of both energy and environmental aims, particularly through the use of the best available and cost-effective control technologies and through improvements in energy efficiency' (Commission of the European Communities, 1985 pp. 21). In 1998, the text vaguely refers to benefits: 'Improved energy efficiency will lead to a more sustainable energy policy and enhanced security of supply, as well as to many other benefits.' (Commission of the European Communities, 1998 pp. 1). In 1993, a link is made between energy efficiency and societal outcomes: 'Improving energy efficiency in all regions of the Community will strengthen economic and social cohesion in the Community' (Council of the European Communities, 1993).

In the 1990s, there is a notable focus on energy 'services', ostensibly to meet consumers' wants and needs: 'One of the most difficult institutional barriers to overcome today is the continued practice of selling energy in the form of kWh instead of as energy services such as heating and cooling, lighting and power. Services are invariably what the energy consumer actually wants, not energy for its own sake' (Commission of the European Communities, 1998 pp. 4). There is more emphasis on end-use consumers than in the decades before, while justifications are made to direct energy efficiency investments into the demand rather than the supply side: 'Least-cost analyses show that investments in demand-side energy efficiency are often more cost-effective than production-side investments' (Commission of the European Communities, 1998: 4). The language concerning actors has changed in the 1990s, with less emphasis on 'educating' people and more on 'enabling' them: 'It is desirable that occupants of … buildings should be enabled to regulate their own consumption of heat, cold and hot water' (Council of the European Communities, 1993 pp. 1). The range of actors is more diversified, with most coming from the energy industry. These include energy service companies/industry, such as manufacturers, distributors, installers, industry associations, branch organizations, utilities and consumer organizations. Other actors include consumers, especially 'end-use' consumers.

Markets as the solution

There is a strong economic focus in the 2000s and 2010s. The framing of market 'barriers' and 'failures' is prominent in these decades to explain challenges to be overcome. For example: 'There is a clear need to improve the functioning of the energy market by removing barriers in order to allow market forces to allocate economic and natural resources effectively' (Commission of the European Communities, 2003 pp. 2). Later in the 2000s, solutions tend to be framed as part of the 'energy efficiency market'. Following developments of the 1990s, the main aim is described as developing a market for energy end-use services,

such as thermal comfort, domestic hot water, refrigeration, lighting comfort and motive power, and for the delivery of energy efficiency programmes and other energy efficiency measures to end users. At this time, the documents tell a story of growth, unlike other decades, claiming that there is immense untapped market potential to realize energy efficiency benefits and improvements that, if solved, could lead to strong economic growth. Proposed solutions are often economic and technical in nature. For example, in 2006, actions outlined in the energy efficiency directive are to increase third-party financing for energy efficiency investments in the public sector and mechanisms to help consumers reduce their energy bills, such as changing billing practices for building occupants.

In 2003, the definition of 'energy service' is closely linked to technology: 'Energy service: The physical amenity for energy end users derived from a combination of energy and energy using technology and, in certain cases, the operations and maintenance necessary to deliver the service (examples are indoor thermal comfort, lighting comfort, domestic hot water, refrigeration, product manufacturing, etc.)' (Commission of the European Communities, 2003 pp. 24).

While the actors mentioned during the 2000s and 2010s are increasingly diverse, they come predominantly from the energy efficiency industry and market – including investors, energy supply companies, energy distributors and retail suppliers, energy service companies, equipment installers and consultants. Consumers are still characterized as people to be acted upon: 'For the market for energy efficiency to be tapped […] the first task at hand will be to inform and convince consumers of the benefits of energy efficiency and to enable them to use energy-efficient technologies and energy efficiency measures effectively' (Commission of the European Communities, 2003 pp. 13).

Energy efficiency benefits

From 2006 onwards, energy efficiency enjoys a headline status in policy with a number of directives referring exclusively to it as an end-goal, most notably in the directives 2006/32/EC on energy end-use efficiency and energy services and 2012/27/EU on energy efficiency. In 2006, the formal definition of energy efficiency gives a broader meaning to the output: 'A ratio between an output of performance, service, goods or energy, and an input of energy' (European Parliament and Council of the European Union, 2006 pp. 67). In 2006, there are major changes in how the energy efficiency targets are measured. The 2006 energy intensity target is amended to measure final inland energy consumption – an indicative energy savings target for Member States to achieve a 9% saving over nine years. The directive

acknowledges that the measure of final inland consumption 'does not provide exact measurements at a detailed level, nor does it show cause and effect relationships between measures and their resulting energy savings. However, it is usually simpler and less costly and is often referred to as "energy efficiency indicators" because it gives an indication of developments' (European Parliament and Council of the European Union, 2006 pp. 114).

In the decade following 2010, the documents emphasize the benefits to be derived from energy efficiency improvements. In 2016, the text states: 'A level higher than 27% energy efficiency in 2030 would bring higher benefits with regard to jobs and economic growth, security of supply, greenhouse gas emission reductions, health and environment' (European Commission, 2016c). In 2018, the text states that energy efficiency improvements will lead to improvements in the environment, air quality, public health, reduce greenhouse gas emissions, improve energy security, cut energy costs for households and companies and help alleviate energy poverty. This will lead to increased competitiveness, more jobs and increased economic activity throughout the economy and improve citizens' quality of life. A 'headline energy efficiency target' is implemented in 2012 to reduce both primary and final energy consumption by 2020, and in 2018 the target is extended to 2030. In 2018, the 'energy efficiency first' principle is applied to energy policy, essentially placing a greater focus on energy efficiency policy options[10]. The document states that the 2012 energy efficiency directive is an element to progress towards the Energy Union[11] under which energy efficiency is to be treated as an energy source in its own right[12].

In this decade, the range of actors mentioned has again increased, though still with a focus on actors in industry and the provision of energy services: 'Cooperation with the private sector is important to assess the conditions on which private investment for energy efficiency projects can be unlocked and to develop new revenue models for innovation in the field of energy efficiency' (European Parliament and Council of the European Union, 2018 pp. 212). Further, there is a focus on ensuring the rights of final customers to fair billing practices and transparent information. These final consumers are defined as 'natural or legal

[10] The 2018 amendments to the 2012 directive explain that the 'energy efficiency first principle' means that 'the Commission should ensure that energy efficiency and demand-side response can compete on equal terms with generation capacity. Energy efficiency needs to be considered whenever decisions relating to planning the energy system or to financing are taken. Energy efficiency improvements need to be made whenever they are more cost-effective than equivalent supply-side solutions'.

[11] The energy union strategy (COM/2015/080) was a priority of the European Commission (2014-2019) aimed at building an energy union that gives EU consumers – households and businesses – secure, sustainable, competitive and affordable energy.

[12] In light of the stronger targets set for energy efficiency for 2020 and 2030, the Commission states that energy efficiency should be treated as an energy source in its own right, representing the value of energy saved (European Commission, 2015). This appears to stem from Commission research showing that by 2030, more energy will be saved than the amount of energy consumed deriving from oil. Using this justification, the Commission states that energy savings can be considered as 'an energy source in its own right'. This depiction may have been inspired by the prominent 2013 IEA report (OECD/IEA, 2013) that found the energy savings from efficiency measures taken over the longer term exceeded the output from any other single fuel source in 11 countries. Here, the IEA uses the data to justify not only that energy efficiency is an energy resource, but could be referred to as 'the first fuel' (IEA, 2013 pp. 3).

persons purchasing energy based on a direct, individual contract with an energy supplier' (pp. 214). The 2018 text also puts a focus on consultation of the directive annex with 'experts': 'To ensure equal participation in the preparation of delegated acts, the European Parliament and the Council receive all documents at the same time as Member States' experts, and their experts systematically have access to meetings of Commission expert groups dealing with the preparation of delegated acts' (pp. 215).

3.4 Discussion

Stone quips that measuring efficiency is like 'trying to pull yourself out of quicksand without a rope' (Stone, 2012 pp. 66). When it comes to efficiency policy, there is no firm ground. Policy objectives and energy efficiency policy are in a constant state of flux, evident in definitions, associations and measurements in each succeeding decade. On the one hand, energy efficiency is a 'motherhood issue' because conserving finite resources is common sense. Achieving savings, too, is a motherhood issue. However, the devil is in the details and the concept must be detangled to see the underlying values at play. Who benefits from policies, how benefits and costs are measured and whether policies are in the end effective are questions that, when pulled apart, reveal values and tradeoffs.

Changes over time

Observing energy efficiency in a historical context shows how policy priorities and historical events are reflected in how energy efficiency is defined and applied in each decade. Perhaps it is no surprise that energy efficiency didn't feature prominently in the energy policy in the 1950s through 1970s, given the dominance of nuclear energy promises and development[13]. Nuclear energy was billed as the fuel that never runs out with promises that it would be 'too cheap to meter' – a perspective far removed from the 'no waste' approach of energy efficiency and conservation policies that became popular later on. Energy efficiency in those decades was aligned with straightforward energy conversion processes of traditional fossil fuels along the energy chain, and actors were mainly energy industry actors such as coal and thermal power plants. The contrast between this conceptualization and the later definitions was stark. In the 1980s, the quantitative definition took on a monetary dimension as energy intensity, putting economic growth in focus in its link with energy production. Energy efficiency was mentioned more in the 1980s,

[13] Although 'energy efficiency' was not specifically mentioned during these decades, efficiency as it relates to energy was mentioned. However, it was conceptualized in a different way and mentioned rarely.

and other strategies to reduce energy consumption mentioned less. This could indicate that the deep global recession of the early 1980s, together with the Three Mile Island accident of 1979 and Chernobyl crisis of 1986, boosted the influence of energy efficiency in policy. According to energy efficiency scholars, the shift towards energy efficiency policy in the 1980s was likely tied to a political shift towards economic priorities of free markets and capitalist expansion (Herring, 2006; Moezzi, 1998; Winner, 1982). Policy actions and discourses across the decades show that priorities generally lie in low-cost solutions. There are examples in each decade showing how cost considerations are prioritized over environmental and social concerns, both in the language used and in the specific policy actions outlined. The economic focus becomes stronger in the 1980s, with 'the market' featuring prominently in EU energy efficiency policy in later decades. This gradually narrows into the 'energy efficiency market'. A shift towards a 'market transformation' globally[14] is strongly represented in the language relating to 'market barriers' that are claimed to impede the realization of the full potential of energy efficiency.

Rhetorical strategies of energy efficiency policy

The definitions and conceptualizations of energy efficiency are generally characterized as being value-neutral, technical and scientific. However, sometimes seemingly uncontroversial definitions and claims made regarding energy efficiency contain evaluative judgements, which act as persuasive strategies. For example, in 2006, energy efficiency is measured as a ratio between energy input and output of 'performance, service, goods or energy'. This characterization of output is subjective, because 'performance, service, good or energy' differs in meaning from one person to another. However, not only were the output definitions linked to subjective 'goods', but they also evolved to contain built-in evaluative judgments. One major theme of the rhetoric across the decades is the idea of a 'free lunch' – that with energy efficiency, we get more for less or, in other words, something for nothing. For example, the energy efficiency definition assumes that there is no loss of comfort or convenience on the consumer's part. In 1974, energy efficiency provides the consumer with 'the same level of output' (Commission of the European Communities, 1974 pp. 5) in contrast to the 'demand restraint of useful energy', which involves a 'sacrifice on [the] consumer's part' (pp. 54). This assumption of stable comfort levels is echoed in 2003. As a consequence, energy efficiency is depicted as a more appealing option than the strategies to reduce energy that involve a restraint on demand and sacrifice on the consumer's part. It is

[14] The 'market transformation' refers to a policy objective to promote energy efficient technologies in the marketplace. The intervention aims to alter market behavior by removing barriers and capitalizing on opportunities to internalize cost-effective energy efficiency practices.

no surprise that energy efficiency was eventually adopted as the preferred strategy for energy reduction in EU policy.

The metaphor that depicts energy efficiency as 'an energy source in its own right' is another example of a free lunch promise. Here, the metaphor links energy efficiency (i.e., energy not wasted) with a tangible fuel. The metaphor is making something that never actually existed – energy that hasn't been used – as valuable as tangible oil, gas or solar energy. Treating these sources as one and the same is methodologically problematic and somewhat misleading – using any given energy source has relative advantages and disadvantages (e.g. cost, location, carbon content), thus, it may not make sense to aggregate them as such. The energy efficiency as fuel metaphor resembles the 'fuel that never runs out' nuclear metaphor. Both depictions have an ethereal tone, as if energy efficiency and nuclear are perpetual energy machines or fountains of youth. But not all that glitters is gold – nuclear energy and efficiency come with hidden costs. Nuclear energy entails hefty upfront and maintenance costs, together with a long pollution life cycle and a risk of serious disaster. Energy efficiency involves investment that is either monetary, time or labor, and runs the risk that energy savings are not as high as expected. In this way, then, these act as stealth metaphors, ones of perpetual energy and false promise.

As energy efficiency becomes more prominent in the policy documents around the 1970s and 1980s, the various strategies to reduce energy consumption are often used interchangeably, hinting that they are honorifics given the same meaning. The terms 'rational use of energy' and 'energy efficiency' are often used together to generally mean less energy wastage and associated with the closely linked virtues of 'rationality', 'prudence' and 'efficiency': 'Rationality' is defined as reaching your goal in the best possible way and 'prudence' means skill and good judgment in the use of resources. While various strategies to reduce energy consumption are well defined and delineated in the literature[15], it is recognized that these terms are often used ambiguously as if they were the same thing in policy and research (Herring, 2006; Moezzi, 2000; Oikonomou et al., 2009; Owen, 2000)[16]. Efficiency scholars argue that confusion over related terms may hamper efforts to effectively reduce consumption, given a lack of specificity of policy actions and targets for absolute energy consumption limits (Franco and Jorizzo,

[15] 'Energy efficiency' is thought of as reducing energy input whilst keeping energy services constant, while 'energy conservation' is often thought of as reducing energy input by reducing energy services (Labanca and Bertoldi, 2018). The rational use of energy is a broad set of actions to reduce energy consumption that include energy efficiency, energy conservation, energy waste reduction, behavior change and the use of renewable energy sources (Franco and Jorizzo, 2019).

[16] In Europe, 'energy conservation' was the preferred term used in policy until 'energy efficiency' replaced it as the policy action of choice to reduce energy consumption (Owen, 2000). On the other hand, in the U.S., The term 'energy conservation' fell out of favour in the 1970s, when it was aligned with 'pain' and 'sacrifice' during the Carter era and oil crises (Moezzi, 2000). It is possible that the 'rational' use of energy was popular because of the influence of the French language in EU policy at the time – the 'rational' use of energy was a favored term in French that aligned with the idea of 'energy efficiency' (*utilisation rationnelle de l'énergie*).

2019; Goh and Ang, 2020). Therefore, communicating concepts relating to energy efficiency is important for effective policy implementation. Efforts were made in 2006, 2012 and 2018 to define energy efficiency and related concepts more accurately than they had been in previous decades. However, these more precise definitions became more complex, linked to a wide range of outputs and benefits. In addition, as the energy efficiency output was attributed to a longer list of benefits, it became a more effective rhetorical device. In the 1980s, energy efficiency promises a free lunch of societal benefits; the text states that energy efficiency measures would create new jobs and industrial activity, and would support environmental aims. Then, in the 1990s, energy efficiency improvements would supposedly bring stronger economic and social cohesion in the European Community. In the 2000s, the promise is largely one of economic growth. These promises are dramatically increased by 2018, when it is claimed that energy efficiency improvements will lead to such benefits as improved air quality, reduced greenhouse gas emissions, improved energy security, cuts to energy costs for households and companies, alleviation of energy poverty, increased competitiveness and economic activity, and more jobs and improvements for citizens' quality of life (European Parliament and Council of the European Union, 2018 pp. 210). Energy efficiency is a panacea to many of the region's problems.

What is left out?

A consistent assumption across the decades is that energy efficiency leads to energy savings and, therefore, reduces energy consumption. This provides the basis for later claims that energy efficiency leads to a reduction in greenhouse gas emissions. Given quantitative uncertainties, though, it cannot be assumed that energy efficiency actions automatically lead to energy savings (Pérez-Lombard et al., 2013). At certain times, the texts mention the issue of uncertainty with relation to indicators and forecasts, stating that energy efficiency measures and projections are not always accurate and should be treated solely as indicators. In the 1980s, for example, a detailed explanation of the weaknesses of certain indicators is discussed. However, in other decades, there is no mention of uncertainties in measures and quantification. It is surprising that no reference at any time is made to the rebound effect[17], despite decades of scientific literature on the topic. To be sure, this literature is contradictory and, as a consequence, the extent and nature of the rebound effect is unknown. Yet it is important not to ignore these uncertainties given that, despite decades of energy efficiency policy actions in Europe, the levels of primary and final energy

[17] In 2017, a question was made by parliamentarian Philippe Lamberts (Verts/ALE) about the rebound effect (https://www.europarl.europa.eu/doceo/document/P-8-2017-007339_EN.html), with a reply stating that the EED impact assessment takes into consideration the rebound effect, with a lower (21%) and a higher (43%) value. It is not clear, however, how the directive handles the uncertainty of the rebound effect, given these two possible scenarios (https://www.europarl.europa.eu/doceo/document/P-8-2017-007339-ASW_EN.html).

consumption are similar to those in the 1990s (Eurostat, 2021), after peaking in 2006 (Tsemekidi Tzeiranaki et al., 2018) and the EU is was likely to overshoot the 2020 headline energy efficiency target (Eurostat, 2021), but it did not due to the COVID-19 pandemic. This is a general trend seen across the globe in recent decades, where, despite more efficient energy production and use, there has not been an absolute nor per capita reduction in energy use (Bertoldi, 2020). The inability to lower energy consumption levels globally has been put down to economic expansion, more production of goods, and greater demand for energy services, thanks to rising living standards in both developed and developing countries (Bertoldi, 2020).

One of the major problems with the quantitative expression of energy efficiency as a ratio is that energy conversion processes measure the rate of energy efficiency of a given conversion rather than measuring consumption overall. In other words, while one machine or appliance can be more efficient than another, it may still consume more energy in total if it is bigger, thus consuming more total energy. This is why, for example, as we purchase more efficient cars, lights and houses, energy consumption does not fall – because we buy bigger houses with more lighting and driving greater distances in more powerful cars. The energy efficiency ratio does not imply a cap or ceiling on consumption levels by default[18]. This tends to obfuscate rising levels of consumption and shut down discussions about caps and limits on production and consumption. Limits are seen as increasingly important as awareness grows about the risks of overshooting our planetary boundaries. This problematic quantitative expression of energy efficiency is coupled with a narrative in the EU policy documents that aligns secure and low-cost energy with ideals of 'progress' and economic and social development. Such deterministic scientific narratives can be dangerous with the implication that the chosen policy actions are the only way to guarantee these outcomes and that lower levels of energy supply will threaten them. Furthermore, these narratives assume that everybody's views on what 'progress' looks like are the same. Consequentially, this leaves little room for alternative narratives that might imagine a world with lower energy consumption – a positive result of different consumption practices and energy sources (see D'Alisa et al., 2014).

[18] It should be noted that EU headline targets are now measured in energy consumption. In other words, the energy efficiency itself is not measuring energy efficiency per se, but the intended consequence of energy efficiency measures – energy savings. The point here is that it is difficult to attribute energy efficiency actions at the micro level with measured energy savings at an aggregated, macro level (Herring, 1999). Further, Member States can choose to measure their efficiency improvements using the energy intensity indicator. Authors have explained the problematic nature of the indictor, mainly pointing to the fact that it often cannot accurately measure underlying technical efficiency nor externalities such as the energy intensity of imported energy. There is thus a common trend in Europe whereby while energy intensity has been reduced, energy consumption has increased (Bertoldi, 2020). Yet, European countries can still choose which indicator they would like to use, including energy intensity, to demonstrate energy efficiency improvements.

The framing of the later documents implies that ambitions to reduce energy consumption will be met by achieving energy efficiency targets, a significant shift from the earlier documents. Over seven decades, energy efficiency evolved from being a set of processes and a methodology, to become a target. Although the effectiveness of energy efficiency targets in Europe have been much debated[19], this chapter focuses on the conceptualizations behind the targets. That is, while attention in the media and in policy is placed on meeting targets and how high targets should be, discussions about how the targets are being defined and measured are less visible – as is what they mean from sociological perspectives. Issues such as limits, accepted consumption levels and quantitative uncertainty are discussed behind closed doors, if discussed at all. The question here is whether putting a focus on targets rather than methods is an effective policy approach. As Strathern states: "When a measure becomes a target, it ceases to be a good measure" (Strathern, 1996). This point is even more important given that targets most likely do not accurately reflect progress due to energy efficiency actions in the first place (Herring, 1999). More emphasis is needed on how efficiency gains are measured. Measures could be altered to include, for example, the life-cycle analysis of products, to take into consideration the energy and pollution footprint of products along their whole lifetimes, rather than solely measuring energy efficiency at the consumer end. Measures could also be altered to take overall consumption more into account rather than simply the comparative efficiency levels of energy conversion processes. There are various alternative approaches to quantification that address problematic issues, including the interrelation between facts and values, inclusiveness and societal tradeoffs (see, for example Kovacic, 2018).

Who benefits?

It is difficult to ascertain precisely who benefits from energy efficiency policy, especially given the complex and uncertain nature of energy efficiency benefits. Some beneficiaries are fairly straightforward to identify from the documents, and are unsurprising. The groups most mentioned over the decades in energy efficiency policy are increasingly those working in the energy efficiency industry and market, including energy efficiency technicians and experts, companies and organizations that undertake and lobby for energy efficiency actions. These groups are the prime benefactors of energy efficiency policies,

[19] According to Jollands (2012), for example, a concern is that setting targets can be an exercise in political publicity – particularly when the burden for achieving the target rests on future politicians. Further, he argues, putting effort into energy efficiency targets can distract policy makers from actually delivering on energy efficiency improvements. One significant problem in recent years has been that European Commission has not been able to resolve how to monitor progress against national energy efficiency targets after several years of trying, partly due to the fact that 'saved energy' is intangible and thus difficult to measure.

given that various pieces of legislation bring with them calls for increased investment into energy efficiency 'market' and its 'services'.

In later documents, the focus is increasingly on the 'final consumer', defined as 'natural or legal persons purchasing energy based on a direct, individual contract with an energy supplier' (European Parliament and Council of the European Union, 2018 pp. 214). A great deal of detail is dedicated to regulations that ensure more transparent billing practices and comprehensive energy consumption information for final consumers. However, the largest consumer of final energy is the industry sector[20], rather than household or services sectors. It is curious, therefore, that more focus is not placed on energy reductions made by industry. This points to a need to better distinguish between types of final 'consumers'. A related point is that there is an omission of the role that consumers may play as 'prosumers'. That is, the more recent texts fail to take into consideration that with changes to the relationship between consumers and providers (for example, with renewable energy technologies), there is a greater role for consumers to play in generating their own energy and managing the supply to the grid (see Chappells and Shove, 2000). With recent easier access to renewable energy technology, we see a push by policymakers to open up the concept of consumers as 'prosumers' (European Commission and GFK Belgium consortium, 2017; European Parliament, 2016). The term assumes that consumers not only consume, but are part of the production process – generating and even selling electricity back to the grid. New technology, governance frameworks and community energy initiatives are offering new opportunities for citizens to get actively involved in energy matters, albeit in low numbers (Caramizaru and Uihlein, 2019).

The focus on energy efficiency services is at times justified by the perceived needs and desires of consumers: 'Consumers want energy services, not energy in and of itself' (Commission of the European Communities, 1998 pp. 4). The consumers are already spoken for – treated as an aggregate entity, as if their needs and desires are one and the same. This is a problem across the decades, with 'people' referred to simply as consumers. In the 1960s and 1970s, nameless experts are depicted as the people who are best placed to make decisions on energy efficiency policy. Later on, markets and technology take a central role, with social concerns relegated to the periphery. In general, people are mostly characterized as energy consumers whose only interest is having energy services with the lowest cost and effort. Based largely on assumptions, this narrow characterization of citizens in energy efficiency policy fails to properly assess citizens' needs and expectations. Missing are energy governance structures and organizational formats that are participatory, inclusive and mindful of the lived experiences of local people (Lennon et al., 2019).

[20] In 2019, the industry sector (32% of final energy consumption) consumes the most energy, followed by the transport sector (28%), households (24%), services (12%) and agriculture and forestry (3%) (https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-3a.html)

These include, for example, energy communities that generate their own renewable energy, with the proceeds going to community interests (for specific examples, see Caramizaru and Uihlein, 2019). The recognition of social issues, such as energy poverty in 2018, is a move in the right direction.

Technology plays a major role in how energy efficiency is conceptualized across the decades. Earlier policy sought to mitigate the conflict between energy and environmental interests with energy efficiency and technology as the 'win-win' solutions to solve disputes. Technology also has played a prominent role in defining energy efficiency in later decades, for example, as 'energy services'[21]. It could be that the lack of focus on people in energy policy is partially due to a prominent focus on seemingly uncontroversial solutions such as technology and energy efficiency. References to 'consumer behavior' become more prominent in later decades, effectively placing more onus on individual energy consumers to reduce their own energy consumption. However, focusing on individual energy consumption in this way presents an overly simplistic conceptualization of how we use energy (Labanca and Bertoldi, 2018). Such narrow frames can draw attention away from aspects that, if changed, could have more overall impact on energy consumption reduction – for example, by addressing power inequalities in energy regimes (Lutzenhiser, 2014; Winner, 1982), exploring more collective and non-commercial solutions (Wierling et al., 2018) and by better understanding how we use energy and why including issues to do with cultural norms and expectations (Shove and Walker, 2014). This includes, for example, more regulation on immensely powerful energy supply companies and more representation and inclusion of citizens in the process of generating and supplying energy.

3.5 Summary

The definition and conceptualization of energy efficiency, while appearing to become more complex over time, has, in fact, narrowed. The concept is a useful political tool and, as a motherhood concept, it is a positively ambiguous euphemism for 'good' and 'virtuous', and its seemingly uncontroversial nature makes it difficult to criticize. It is no surprise that European institutions have invested heavily in the concept both in monetary and in policy terms. An increasing list of benefits has been attributed to energy efficiency, including its ability to provide energy services for less energy input and less cost, with no reduction in comfort. However, the historic and current conceptualization of energy efficiency omits

[21] In 2003, energy service is defined as: 'The physical amenity for energy end users derived from a combination of energy and energy-using technology and, in certain cases, the operations and maintenance necessary to deliver the service (examples are indoor thermal comfort, lighting comfort, domestic hot water, refrigeration, product manufacturing, etc.) (Commission of the European Communities, 2003 pp. 24)

important points, limiting its ability to solve contemporary complex problems such as reducing energy consumption and greenhouse gas emissions. Studies of energy efficiency need to be more focused on how it is measured and what tradeoffs occur as a result. Historical analyses show that policies that imply a limit on energy services and consumption can easily be sidelined in favour of so-called 'win-win' solutions, namely energy efficiency and technological innovation, which do not necessarily lower energy consumption.

Chapter 4 – The politics of measurement: the case of energy efficiency

4.1 Introduction

In-between 2016-2018, a process took place to amend the Energy Efficiency Directive 2012/27/EU (EED). The EED sets the rules and obligations for the EU's 2020 and 2030 energy efficiency headline targets. Before the file reached the European Parliament ('EP'), there was an expectation that the political debates were likely to focus more on the level of the targets, i.e., the 'ambition' in percentage terms, rather than their substance (i.e., the methodologies used to calculate the headline target indicators). What happened in practice, however, was that the rapporteur in charge of the energy efficiency file in the EP proposed a significant overhaul in the way that energy efficiency was defined and measured. The action led to a struggle over the meaning of energy efficiency itself – including the way it is measured, described, conceptualized and applied in practice. In so doing, it opened up a space with which to observe different versions of energy efficiency as described by different actors. These include as a ratio between either primary and final energy or economic growth and energy consumption (i.e., energy intensity), or energy savings and overall lower energy consumption. This conceptual ambiguity is a problem that has been highlighted in both the scientific literature and the policy arena – especially the interchangeability between energy savings and energy efficiency. Authors (Goh and Ang, 2020; Patterson, 1996; Pérez-Lombard et al., 2013) have sought to clarify the definition of energy efficiency to avoid this ambiguity, explaining that the different ways of conceptualizing and calculating energy efficiency indicators have different implications for the effectiveness and outcomes in policy. My aim to is to bring these conceptual insights together with the sociology of quantification and the study of the situated material practices of policymaking. This chapter takes these political negotiations as a case to explore how the conceptualisation and measurement of energy efficiency is not simply a 'technical' discussion, but one where scientific and methodological aspects are entangled with political, societal and environmental issues to create a governable object that is energy efficiency.

4.2 The politics of energy efficiency measurement

Authors have highlighted the confusion in the academic, policy and grey literature among energy efficiency and other related terms, for example energy conservation (Moezzi, 2000; Oikonomou et al.,

2009; Owen, 2000) energy demand ((Bergman, 2019) and energy savings (Goh and Ang, 2020). As discussed earlier in Chapter 2, Energy efficiency is generally conceptualized as a ratio of energy input (e.g. kwH of electricity) to the output of useful energy services (e.g., light or heating). An 'improvement' in energy efficiency thus implies that one is using less energy for the same level of service or output, resulting in 'energy savings'. As already pointed out, though, energy efficiency does not necessarily imply an overall reduction in energy consumption, just that one is using energy at a more efficient rate, due, especially to, technical change and innovation (Calwell, 2010; Moezzi, 2000) or the behaviour change of consumers to reduce energy consumption (Barbu et al., 2013). What this means is that energy efficiency is a ratio, not a quantity. For example, a clothes dryer that is labelled energy efficient may use a more efficient work rate of energy input to energy service output (i.e., clothes drying). However, if the user decides to use the dryer on a more frequent basis, it may consume a higher overall level of energy. Another strategy to reduce overall energy consumption would be to dry the clothes in the sun.

Many arguments have been made that more precise definitions of energy efficiency can improve the field's understanding of what is at stake and what the tradeoffs are for any give indicator. Authors have sought to explain what energy efficiency is and why the implementation of the concept of energy efficiency is so problematic in practice (Goh and Ang, 2020; Patterson, 1996; Sorrell, 2015; Velasco-Fernández et al., 2020). As noted in Chapter 2, one problem this strand of literature points to is that energy efficiency is framed too narrowly and, as a consequence, leaves out variables that are important to energy conversion processes. Among these are e.g., energy qualities and their compositions, environmental sustainability, pollution displacement, the durability of materials and power (Patterson, 1996; Velasco-Fernández et al., 2020). Chapter 2 also highlighted another major methodological problem is that it is difficult to show the additionality of energy efficiency actions, particularly at the aggregated level, known as the 'rebound effect', the mechanism whereby expected savings are reduced (Brockway et al., 2021). Many of the methodological and theoretical challenges and alternatives outlined above, however, are rarely cited or publicly acknowledged in EU energy efficiency policy. Much of the literature on energy efficiency policy is focused on improving policy design and reducing 'barriers to energy efficiency improvements' (Reddy, 1991), rather than examining methodological limitations of the concept itself, and how these are manifest in quantitative representations such as indicators. For example, research on energy efficiency policy has focused on the level of energy efficiency targets (Harmsen et al., 2014), National Energy Efficiency Action Plans (NEEAPS) (Bertoldi, 2013) and energy efficiency governance, which examines predominantly institutional and organizational considerations in efficiency policy (Jollands and Ellis, 2009). Chapter 2, however summarized the lively debate on these issues in the social sciences and humanities (SSH) field, that suggests that the concept itself is problematic, as it contributes

to perpetuating the problems that it is meant to solve. The argument is that, by focusing on relative rather than absolute levels of consumption, energy efficiency supports the continuation of high levels of energy services and comfort rather than encouraging behaviour change or more sustainable energy practices of energy consumers (Herring, 2006; Princen, 2005; Shove, 2017). In line with this view, there is a growing movement of academics and energy efficiency practitioners who call for a different approach to reduce absolute energy consumption, called 'sufficiency' (see e.g., 23–25). Unlike energy efficiency, which denotes a constant or rising level of energy services consumption, sufficiency implies consuming 'enough' energy and energy services in order to not surpass the earth's natural limits, such as natural resources extraction and carbon load.

What is lacking in the energy efficiency policy literature, however, is research that unpacks the political aspects of energy efficiency indicators empirically. This study does this by exploring the "indicator politics" at play, together with the technical and methodological aspects highlighted in the energy efficiency literature. The argument is that indicators are necessarily political as they involve decisions that go beyond the mere technical level (Merry, 2016; Turnhout et al., 2014). As Merry (2016, pp. 21) puts it: "The technical is always political because there is always interpretation and judgement in systems of classification, in the choice of things to measure, in the weighting of constitutive elements, and in decisions about which denominator to use for a ratio." Furthermore, the development of indicators is not merely about the neutral measurement of a pre-existing object "out there", but rather involves the production of an object as legible and governable (Völker et al., 2020). By this we mean that the way in which an entity is quantified and measured, such as energy efficiency, is far from self-evident. The various aspects and dimensions that enter a set of indicators are often a matter of mundane considerations such as data availability, methodological preferences and skills.

Finally, indicators are tied to certain modes of governance. Turnhout et al. (2014) show how governance logic espousing neoliberal ideals of transparency, effectiveness and efficiency (dubbed 'measurementality'), when applied to European mapping and monitoring systems, creates a particular understanding of ecosystem that may lead to an impoverished understanding of biodiversity. In a similar manner, Kristin Asdal, (2008a) describes how the concept of 'nature' is unified as a whole through practices of economics and accounting.

So far, there is very little research that systematically combines a study of the methodological challenges of energy efficiency implementation with these kinds of political dynamics to ask questions about what is quantified, what is left out and what issues co-emerge with the ways that energy efficiency is currently

discussed as a quantifiable and governable object.

4.3 Enacting energy efficiency through parliamentary 'thing work'

I draw on analytical concepts taken from the field of Science and Technology Studies (STS) that can zoom in on material-semiotic practices through which different objects of governance are enacted (Asdal, 2008a, 2008b; Callon, 2021; Law, 2009). The starting point for this form of inquiry is exactly the assumption that such objects are not simply "out there", but rather the outcome of these practices. In particular, procedures and methodologies of quantification and measurement play an important role in this line of inquiry. In her work on the European 'critical load project' that aimed at quantifying how much pollution is still acceptable, Kristin Asdal (2008a) asks how a new 'Nature-whole' is enacted through quantification and how it becomes consequential in politics. The notion of enactment in her work addresses "the ways in which the heterogeneous materialities and practices of science and politics produce the relevant entities and objects which accordingly take part in public and political life." (29, pp.124). The argument here is that the very idea of 'limits of nature' only emerged and became relevant for economic practices as a certain enactment of nature through the discussion of critical loads. In a similar manner, John Law (31, pp. 239) talks about scientific methods as "practices that do not simply describe realities but also tend to enact these into being.". This argument points not only to the performative features of method and measurement, but also highlights the importance of political work and "the little tools of governance" (Asdal, 2008b), that are the "mundane epistemic and administrative tools and practices" aimed at "producing controlled, objective and non-politicised situations and objects." (ibid. pp. 16). The latter part of the quote is crucial to keep in mind: the default mode of bureaucracies is to create non-political objects and situations (Asdal, 2008b; Barry, 2001).

What makes this perspective useful for this work is that it allows me to understand discussions about the energy efficiency directive, not as a debate 'merely' about questions of proper definitions and methodologies of measurement, but instead as a moment in which a certain version of energy efficiency as an object that can be measured and governed was turned into a politicized issue. Understanding this moment through this lens allows me to zoom in on how the technical gets woven together with political and organizational orderings as well as with implicit normative assumptions about the common good and desirable futures. Energy efficiency as a 'thing' that can be measured and governed is thus the temporally stabilized outcome of this ongoing debate, not its starting point.

In this chapter, I unpack a controversy in the EP that went beyond the usual topics – level of ambition of targets – to argue how energy efficiency should be defined and measured. In doing so, we aim to carve out an understanding of how a certain version of energy efficiency was stabilized through establishing a particular assemblage of the technical-methodological with the social, organizational, legal, and normative.

I ask the following questions:

- How did the political procedure contribute to the stabilization of energy efficiency as a governance object?
- How did the concrete political procedures – the 'thing-work' - itself contribute to a certain enactment of energy efficiency at the expense of others? Through which 'little tools' – both epistemic and political/administrative was this achieved?
- What versions of democracy, publics and citizens co-emerged with these enactments?

By addressing these questions, the research aims to contribute to the debate on energy efficiency quantification with an empirical perspective that shows how the procedures and 'little tools' of EU policymaking become instrumental in stabilizing energy efficiency as a governable object.

4.4 Methods

This chapter applies a case study approach combining document analysis with expert interviews. Legislative documents relating to the energy efficiency directive were identified and collated using a saturation approach (Saunders et al., 2018), during the time period June 2016 - December 2018. These included, principally, European Commission ('Commission') impact assessments, parliamentary reports, public debate transcripts and working documents. Desk research was used to identify major themes. News directly relating to the energy efficiency file were collected from news websites (*Euractiv, Political Pro*) during 2016-2018. The news stories complemented the institutional texts with additional themes, context and timelines. Twenty-one semi-structured interviews were conducted with policymakers, policy officers and independent academics in order to validate and deepen the results of the document analysis. Interviewees include parliamentarians and/or their assistants who worked directly on the EED file from the Socialists and Democrats (S&D), European People's Party (EPP) and Alliance of Liberals and Democrats for Europe (ALDE) parties. Two representatives from the Commission were also interviewed.

From this initial sample, policy analysts, academics and energy efficiency specialists who had experience and knowledge of the file were identified through a sampling technique. The interviews lasted 60 minutes on average and were treated as expert interviews. A thematic analysis was applied to the data (Bogner et al., 2009; Silverman, 2006). The interviews were used as a base from which to expand on topics main themes from the document analysis.

4.5 Politicising the way energy efficiency is defined and measured

In November 2016, the Commission presented a proposal to revise the 2012 EED as part of the 'Clean Energy for all Europeans' package. According to the Commission, the EED was amended to meet EU climate and energy targets for 2030 and align it with other aspects of the Clean Energy package, which included renewable energy and carbon emissions. In its public consultation, conducted between 4 November 2015 to 29 January 2016, the Commission reports that most contributions were submitted by industry associations (140), private companies (47) and NGOs (33), and 18 central public authorities, with the remaining 13 representing Member States (European Commission, 2016c). In February 2018, the three main institutions involved in EU legislation: the EP, the Council of the European Union ('the Council') and the Commission, began a number of interinstitutional negotiations to form a consensus on amendments to the EED. During the various Council, parliamentary and trilogue negotiations, there were differences of opinion over the level of ambition for the 2030 headline energy efficiency target. In the media, it was generally framed as a straightforward debate pitting actors – including policymakers, parliamentarians and Member States - who wanted a higher target, against those who wanted it to be less. Headlines read, for example: "EU remains split on energy efficiency ambition"(Gurzu, 2017a), "MEPs divided on energy efficiency ambition"(Oroschakoff, 2017) and "Commission laments member states' lack of ambition on energy saving laws"(Morgan, 2017). A closer look at the policy documents tabled during the process, however, tells a less clear-cut story.

Following the EU's Ordinary Legislative Procedure (OLP)[22], in 2016 the Commission presented its proposal for amendments together with an impact assessment. These were then debated by Energy

[22] The Ordinary Legislative Procedure is the standard decision-making process in the EU. In the system, the directly elected EP has to approve EU legislation together with the Council (the governments of the 27 EU countries). The procedure starts with a legislative proposal from the Commission. Before its proposal, the Commission prepares impact assessments that assess the potential economic, social and environmental consequences of possible policy options. The Commission formulates a proposal and addresses it to the EP first, which can adopt, reject or amend the proposition. A Member of the EP, working in one of the parliamentary committees, draws up a report on a proposal for a 'legislative text' presented by the Commission. The parliamentary committee votes on this report and, possibly, amends it. When the text has been revised and

Ministers in the Council. Once a proposal reaches the EP, its role is to form consensus among parliamentarians and present their proposals as a plenary resolution to the Council for negotiation/agreement. The EP's Committee on Industry, Research and Energy (ITRE) was responsible for managing the energy efficiency directive, including writing the parliamentary report and managing the interinstitutional negotiations. The ITRE energy efficiency file was led by a Polish rapporteur from the S&D group, Adam Gierek, who also represented the Democratic Left Alliance-Labour Union (Unia Pracy) Party in Poland. Prior to his parliamentary term, Mr. Gierek was an engineering professor of smelting and material science. He had been on the ITRE committee since 2004, and had significant experience in energy matters in parliament. The expectation of Mr. Gierek was that he follow his Party's line to support a 40% energy efficiency target by 2030. This was an ambitious stance compared to the Commission (30%) and Council (30%) proposals. As the rapporteur, he was tasked with securing the highest possible target as an outcome of the trilogue negotiations[23].

The ITRE draft report (ITRE, 2017) presented to Parliament in May 2017 was unusual in that it proposed significant changes to the directive. It sought to unpack and explain the problems with the calculation of current indicators and alternative solutions to them. In doing so, the ITRE report created a version of energy efficiency that was distinct from that of the Commission. Specifically, it proposed to calculate energy efficiency through the indicator of cumulative primary energy consumption, rather than the separate primary and final energy consumption indicators that the Commission had proposed, and that the directive originally stipulated in 2012. The argument for this change was that the current indicators did not measure energy efficiency comprehensively enough across the economy – i.e., that parts of industry were omitted from measurement and they needed to be measured in order to make them more efficient. These gaps, the report maintained, were notably the energy conversion processes between the primary and final energy stages, "precisely where the links in the energy flow chain that have huge efficiency increase potential and reserves"(ITRE, 2017).

The proposed methodology therefore included what it saw as the overlooked parts of the energy chain, including primary energy production and conversion (extraction and transportation of raw materials prior to processing into electricity and/or heat). This would be added to the sectors already included in

adopted in plenary, Parliament has adopted its position. Then, the EP's opinion is transmitted to the Council that can reject/accept or put forward its own modifications. Once the text is agreed upon, the two co-legislators adopt legislation jointly, having equal rights and obligations.

[23] Agreements between the co-legislators are often reached through tripartite interinstitutional negotiations ('trilogues') between the EP, Council and the Commission.

measures such as the electricity, housing and consumption sectors [24]. Thus, ITRE's enactment of energy efficiency focused more on production, rather than consumption systems. The ITRE report maintained that the aim was to put more onus on energy producers, generators and distributors to make energy efficiency improvements, rather than focusing the burden on energy consumers at the end of the chain, as the Commission had proposed, which the ITRE report argued "would not put enough responsibility on energy providers to modernize their energy production systems with a mind to deliver energy that is efficient in conversion and transfer efficiency" (ITRE, 2017)

Energy poverty was a central theme in the parliamentary discussions. The ITRE report argued that focusing on the upstream energy processes would take the burden off consumers at the final stage to make energy savings, thus helping to alleviate energy poverty. In this particular enactment of energy efficiency, the division of political landscapes between rich and poor and Eastern and Western Member States was highlighted. In Mr. Gierek's native Poland, there was reportedly "little patience with expensive energy efficiency solutions that will hurt poorer people" (Gurzu, 2017c) – i.e., energy efficiency improvements at the consumer end. Mr. Gierek said that obliging consumers in poorer member states to reduce their energy consumption was unfair because "people in poorer countries like Poland and Romania use half the energy of Germans or the French and a third of what Swedes consume" (Gurzu, 2017b).

In contrast, the Commission's argument was that a focus on end-use consumption was precisely the key to reduce energy poverty. Its proposal included targets for energy consumption reduction and energy savings in end-use sectors, (known as 'Article 7'). The rationale for targeting the end-use consumer sector was that by reducing energy consumption, consumers would save money in energy bills: "High energy bills and energy poverty are a major problem in many Member States. In particular, 11% of European citizen cannot keep their houses warm in the winter. Also, companies suffer from high energy bills due to competitive disadvantages, in particular energy intensive industries (large and small) but also in the service sector. Therefore, energy efficiency policies should in particular target end consumer sectors to improve their situation." (European Commission, 2016b, pp.73)[25].

[24] The report argues that "Using only primary energy would pave the way for a better focus on the entire energy supply chain, including upstream processes (extraction and transportation of raw materials prior to processing into electricity and/or heat). It would also take full account of all final consumers' savings through the use of primary energy factors."

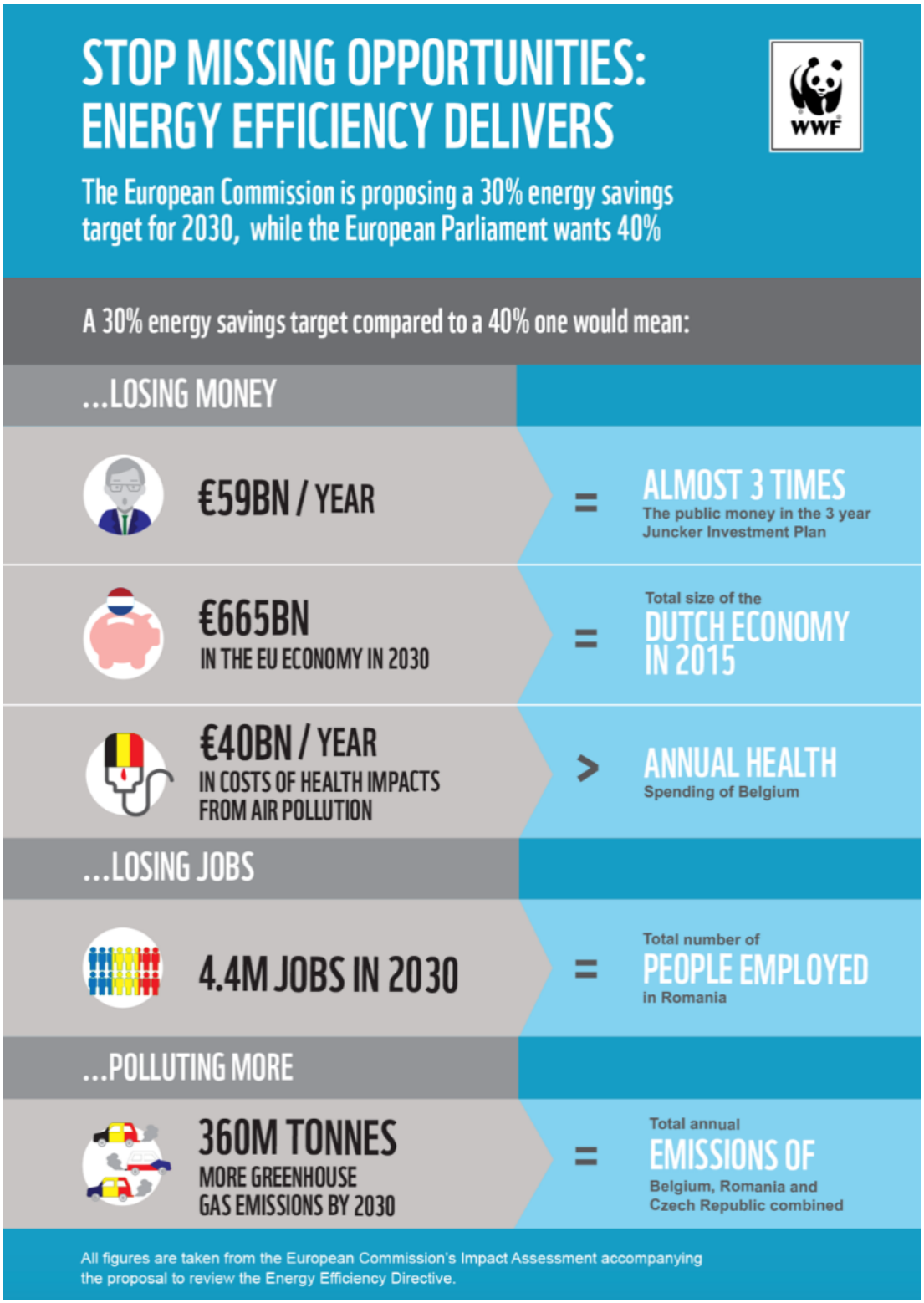
[25] In addition to the headline indicator, the ITRE report also proposed that methodologies capture pollution displacement (e.g. through lifecycle analysis) and new, more precise formulas for calculating the Primary Energy Factor (PEF), which captures the rate at which energy conversions are calculated.

Reaction to the ITRE report

The report caused upset in Parliament following its release, with some 600 amendments submitted by MEPs (Stefanini, 2017). *Politico* reported that the message from S&D parliamentarians was confusion over the report. Many were having difficulty understanding it, describing it as 'very academic'. "Frankly speaking, politicians don't understand technicalities," Mr. Gierek responded (Gurzu, 2017b). He went on to explain that he was approaching the file from a technical, not political, point of view, *Politico* further reported. One expert interviewee said "his ideas didn't cut through the political discussion at all". The move that caused the greatest rift within his Party, however, was that in an unusual move, Mr. Gierek had not followed his S&D group's line in support of a 40% headline target. Instead, he supported 35% in his report, claiming that, as the rapporteur, he could achieve wider support "for a more realistic target" (i.e., one that is more easier to negotiate with the EP and EU institutions). Mr. Gierek, however, said he would not rule out supporting the 40% energy efficiency target on the condition that all three stages of the energy flow (i.e., those according to his proposed methodology) were included (Denková, 2017). He argued that applying his measure across the whole energy chain with a 35% target would be more effective in improving energy efficiency than by using the current methodology with a 40% target.

This point, however, was submerged amid the debates that centred on the numbers. The cost-benefit analysis in the Commission's 2016 impact assessment (European Commission, 2016b) was central to discussions. It looked at different headline indicator options, including 30%, 35% and 40%, taking into consideration the cost, social and environmental benefits of each. The conservative parties (European People's Party (EPP) and European Conservatives and Reformists (ECR)) tended to support the lower target of 30%, claiming that a higher one was too expensive. Mr. Gierek argued that a 35% target was the optimal level because the impact assessment showed that "the closer we get to 40%, the more costs rise significantly" (ITRE, 2017). The parliamentarians supporting a higher target, including the S&D party, argued that the social and environmental benefits outweighed the costs. Some NGOs and industry groups used the impact assessment to argue for a highly target. WWF, for example, released an infographic showing the trade-offs in implementing a 30% versus 40% target, based on the impact assessment.

A flyer published by NGO WWF (WWF and JQ Visual Communications, 2017) detailing the differences between a 30 and 40% target



NGOs and stakeholders weigh in

Mr. Gierek was weakened further politically following the release of the report's English version (12 June, 2017), when it received criticism from NGOs and industry groups. These criticisms saw the focus on primary energy as favoring the coal industry and argued that drawing focus away from end-use consumption would fail to address energy poverty. The European Environmental Bureau said: "Changes proposed by the MEP go beyond the scope of the Directive, even attempting to redefine the entire concept of energy efficiency […] "The report's focus on primary energy savings in power plants, transmission and distribution loses sight of the potential for citizens and final users to make gains" (European Environmental Bureau, 2017). Friends of the Earth Europe said: "According to Mr. Gierek, energy poverty can only be fought by making power plants more efficient, de facto supporting so-called cleaner coal. This focus on primary energy disregards the opportunity to act on one of the root causes of energy poverty: leaky, inefficient homes that waste energy and drive up bills"(Hutin, 2017). Climate Action Network Europe stated: "[Polish MEP Adam Gierek], proposes to dismantle future EU energy efficiency policy and promotes measures that would extend the life of coal power plants (Climate Action Network Europe, 2017).

Industry, too, weighed in, including, notably, industries set to be affected by his proposed changes. EURELECTRIC, a federation representing the electricity industry in Europe (more than 3,500 companies in power generation, distribution and supply), said the proposals for a new methodology would hamper electrification efforts and undermine efficiency improvements and decarbonisation in Europe. "EURELECTRIC is concerned that the profound changes to EU energy efficiency legislation proposed in Gierek's draft report go in the wrong direction and risk jeopardising the delivery of cost-effective energy efficiency improvements in the EU" (EURELECTRIC, 2017). More than 50 companies and business organisations in industries that would most likely benefit from a focus on end-use efficiency, such as glass manufacturing, lighting, insulation, electricity and other companies, sent a letter to Mr. Gierek and his parliamentary colleagues asking him to support the Commission's original proposal for energy efficiency to be expressed both in primary and final energy terms, "to ensure a holistic approach to energy efficiency investments and services and provide a legal basis to the promotion of both end-use and generation and distribution efficiency". (European Alliance to Save Energy et al., 2017).

Eventually, under pressure from his party, the rapporteur changed the proposed target to 40% in his report. A number of amendments were tabled and negotiated. Many of the original proposals to change the way energy efficiency is defined and measured were omitted, including the calculation of cumulative

energy and the energy efficiency definition. Unable to support the new report that conflicted with his position, Mr. Gierek abstained from the vote to approve it, which was endorsed narrowly by the ITRE committee on 28 November 2017 (33 votes in favour, 30 against, 2 abstentions). The rapporteur then stepped down, on December 5th, to be replaced by another rapporteur, Miroslav Poche from the Czech Republic. The report to be presented to the wider parliament for debate, therefore, was much less radical, and less complex than that presented by Mr. Gierek.

Methodological issues re-emerge in parliamentary debates

Methodological issues remained a concern for some parliamentarians. One of these was about the calculation of the rebound effect. On 29th November 2017, Philippe Lamberts (Verts/ALE) asked the Commission how it factored in the rebound effect when drawing up its objectives and proposals relating to energy efficiency[26]. The Commission posted its reply almost two months later, on January 17, 2018 - the same day that the parliamentary report was adopted as a plenary resolution (i.e., at a stage that was too late for the EP to make changes). The Commission responded[27] that the rebound effect was included in modelling for the impact assessment, using two values based on a literature review: 21% and 43%. The significant range of these two figures highlights the extend of uncertainty in the energy efficiency literature regarding the rebound effect. The Commission explained that when modelling the first scenario of 21% rebound, sufficient savings would be delivered to reach a 30% energy efficiency target in 2030. The second value of 43% rebound effect, however, involved more uncertainty in that it "would require additional measures (such as the recently proposed post-2020 CO2 standards for cars and vans)". Despite this clarification, however, the complexity of the rebound effect appeared to hamper decision-making, as one key informer noted: "It was such a difficult concept […] that not a lot of people were mastering. So, as a result, I think it is also something that was a bit pushed to the background, because people didn't really want to take a decision on it".

[26] https://www.europarl.europa.eu/doceo/document/P-8-2017-007339_EN.html

[27] The debates were held on 15 January 2018 and 12 November 2018, see: https://www.europarl.europa.eu/doceo/document/P-8-2017-007339-ASW_EN.html

Focus on achieving consensus

Methodological issues were raised during two parliamentary debates on the energy efficiency file[28]. Parliamentarians, however, attempted to steer discussions firmly back to the negotiation of the headline target. Mr. Gierek had been replaced as rapporteur by the time the first debate had begun in January 2018, but he continued to argue his position with regards to his methodology. Mr. Gierek asked the S&D's Kathleen Van Brempt to explain how energy efficiency was calculated, after she reiterated her support for a 40% target. Van Brempt replied "I'm not sure – because that was one of the difficulties – that I understood your question fully […] I do not exactly understand your question, but I can assure you that in the philosophy of what our political group wants, it is 40% by 2030." Mr. Gierek responded by explaining what he called the 'technical' definition of energy efficiency. He did this by treating energy efficiency as a ratio between primary energy and final energy, which determines the efficiency of the system. He argued that under this scenario, reaching 40% was a technical impossibility if the system efficiency was already 63% (i.e. 40+63% = >100).

The problem here, however, was that the two politicians were supporting different methodologies of calculation that cannot be compared. Mr. Gierek was defining energy efficiency as a ratio, explaining that "Energy efficiency is the percentage of energy obtained each time it changes from one state to another. It can be a percentage of final energy in terms of primary energy, or a percentage of usable energy in relation to final energy." Van Brempt, on the other hand, was supporting the Commission's proposal, which is based on reductions in total energy consumption (i.e. whole numbers), not a ratio. The target (including the 2020 and 2030 targets) is based on an estimation of future energy use (in this case, 2030 consumption) and the target is the ambition to lower that target by a percentage amount (European Commission, 2016b; IEA, 2017). Thus, the target cannot be compared to Mr. Gierek's definition, because it is not a ratio and therefore cannot exceed 100%. During the debate, Mr. Gierek found support from across the party divide, especially from his Polish colleagues. Ms. Jadwiga Wiśniewska from the ECR argued that "When it comes to energy efficiency, Professor Gierek's proposal to calculate it in relation to primary energy is rational and scientifically justified."

However, the other parliamentarians attempted to focus the discussion on forming consensus on the headline target. The Shadow Rapporteur for the PPE group, Markus Pieper, said: "Mr. Gierek, I know

[28] The debates in January and November 2018 also included the reports on proposals for Governance on the Energy Union and renewable energy).

that you can scientifically substantiate that we are doing a lot of stupid stuff here. But we are politicians, and politicians must also be able to ultimately reach compromises." Similarly, the Parliamentary Vice-President, ALDE's Pavel Telička, said that it was important to move on from the methodological issues and achieve a clear majority vote to strengthen the EP's negotiating position in the trilogues: "I regret on some of the issues we were unable to maintain a broader coalition due to issues which are difficult to comprehend. So let us do a serious vote and let us send out a message and create a good basis for negotiations, because this is key and we do have to be ambitious and realistic".

The parliamentary report was adopted with a clear majority on January 17, 2018 as a plenary resolution (485 votes in favour, 132 against, 58 abstentions). Mr. Gierek's ideas had gained the support of 51 (largely Polish but cross-party) MEPs. His proposals, however, were not adopted, and he voted against key amendments put forward by his S&D group in the committee vote. The plenary resolution supported a binding EU target of at least 35% efficiency improvements by 2030, to be calculated using the Commission's original proposal, in primary and final energy consumption, and achieved by means of indicative national targets[29].

Controversy about what energy efficiency means

Mr. Gierek was again vociferous in the second debate in November 2018, arguing that the directive did not measure 'real' energy efficiency as he saw it: "Commissioner, the efficiency directive is, in my opinion, a legislative failure, because it concerns restrictions on the use of energy and not real efficiency […] today's vote doesn't show the real solution. The people who voted for the amendment don't understand what it's about. They voted for savings, but that's not efficiency." What he meant was that limits should be placed on primary energy rather than on final energy. In particular, he opposed Article 7 of the directive, which set targets for energy savings. Again, Mr. Gierek was supported by Jadwiga Wiśniewska who said that Article 7's focus on final energy consumption was "confusing energy efficiency with saving energy [...] this will threaten economic growth and increase energy poverty". Others from the conservative parties (EPP and ECR) agreed that energy efficiency should be distinguished from energy savings. One informant said: "Within our group we had a very strong opinion that energy efficiency doesn't mean energy saving; energy efficiency is input of coal and output of one unit of GDP". (i.e. energy intensity). The EPP and ECR also put forward a proposal in the compromise

[29] Strengthened provisions on annual (end-use) energy savings obligations were added, and included a broader range of sectors than in the original Commission proposal, including buildings, transport, heating and cooling,

amendments (European Parliament, 2017) which stipulated that Member States could discount from the measures extra energy consumption that was consumed in the case where economic growth was higher than expected[30]. This proposal was voted down.

Energy efficiency, however, meant something different to the other policymakers. Those from the ENV working group and left-leaning parties tended to describe energy efficiency as a strategy to limit consumption and achieve energy savings, sometimes mixing the ideas of energy efficiency and savings together. The S&D's Jytte Guteland who was energy efficiency rapporteur for the Committee on Environment, Public and food Safety (ENVI), said: "I was delighted to get the ambition of the Committee on the Environment to 40 percent energy savings by 2030 […] With a goal of 32.5 percent more energy efficiency by 2030, hundreds of thousands of new jobs will be created in Europe, while climate emissions will decrease, our fossil fuel imports will decrease and health will improve." Pavel Telička (ALDE) also aligned energy efficiency with reduced consumption: "We need to focus on the other side of the coin: reducing consumption […] with an emphasis not just on the opportunities in terms of technology, renewables, etc. but also on lowering consumption". The Commission had stated its definition in its impact assessment, that energy efficiency was not about conservation, and should not prohibitively limit consumption. "What the energy efficiency policies aim at is not to cap the absolute amount of energy consumed in a manner that could turn out to be prohibitive in times of high economic growth or a very lax target in times of economic slowdown. Instead, energy should be used in a more efficient way (i.e., using less energy per unit of economic output)" (European Commission, 2016 pp.75).

Parliament negotiates a deal with the Council

Following the first debate and the EP's plenary resolution, trilogue negotiations between the EP, Council and Commission began in February 2018. Major changes were negotiated, effectively watering-down the proposed headline target. One element was to loosen the requirement for EU countries to make energy efficiency improvements, by removing the obligation to meet *both* primary *and* final energy consumption targets. This went against what the Commission and the EP had wanted. Instead, an option was written into the text to achieve *either* primary *or* final energy as the Council had pushed for[31]. This meant that countries could focus on only one part of the target rather than both, i.e., that some industries could

[30] "Where a Member State has not based its contribution on energy intensity, it may detail in its integrated national energy and climate plan […] its expected level of industrial output in 2030 and may subsequently exclude from counting towards its contribution for 2030 any energy consumption resulting from excess industrial output." (European Parliament, 2017 pp. 5).

[31] The final text read: "has to be no more than 1,321 Mtoe of primary energy and/or no more than 987 Mtoe of final energy

potentially be left out of the measurement. According to one informant, this issue had been a major sticking point since 2012, when France and Finland argued to focus only on final energy consumption because they were concerned that a focus on primary energy would incentivise reductions in nuclear power in their domestic debates. The Commission had explained in its impact assessment why it was important to include both primary and final energy consumption in the indicator (European Commission, 2016b). It said that if only final energy is counted, then it would generate changes in industry, residential, transport, services and other final sectors, and not in the generation sector and energy networks where "huge energy efficiency potentials exist." (European Commission, 2016b). The opposite would be true if the focus was only on primary energy: "Member States could achieve their target without generating any savings in the final energy consumption sectors (e.g. in buildings) if the target is expressed in primary energy consumption only. [If this were the case] Member States could e.g. focus on a shift towards more renewable energies only, instead of aiming for energy efficient housing." (European Commission, 2016b, pp.75).

Towards the end of the trilogue negotiations, there were calls among industry campaigners and the Commission to keep both indicators in the target. Paul Hodson, Head of Unit for energy efficiency at the Commission, said that keeping with the original "and" formulation "could be 1% different in ambition from having a target that is expressed as being so much in primary or so much in final. That's really quite important and not at all obvious," Hodson told delegates at the annual conference of COGEN Europe (European Association for the Promotion of Cogeneration Europe) on 5 June (Simon, 2018). COGEN Europe also lobbied for a focus on primary energy, arguing that more emphasis should be placed on making savings in the production and distribution of electricity because of average losses of 60%, a figure which can reach 75% for power plants running on biomass, they said. "As long as the electricity sector is not 100% efficient, measuring energy efficiency in primary energy should be considered first" (Simon, 2018). These calls were not applied, however, and as a result of the trilogues, a provisional agreement was reached on 19 June 2018 that set an indicative EU target of 32.5 % efficiency improvements by 2030, and the final text was signed into law on 10 December 2018.

Response to the Commission's impact assessment

In April 2018, the European Council for an Energy-Efficient Economy released a report (ECEEE, 2018) that found that the Commission's 2016 impact assessment miscalculated the estimated costs required to

meet the energy efficiency targets[32]. The study stated that if the Commission had used the member state average discount rate, costs would have been lower and negotiators could have been freer to push for higher targets and annual savings.

4.6 Discussion

This case study offers insight into a political struggle that revolved around the definition and quantitative articulation of energy efficiency. The case is unique because the administrative space was broken open during the policy process whereby Mr. Gierek was able to produce, not the ordinary object that was anticipated, but an extraordinary one. He defied protocol in his attempt to rewrite the Commission proposal of amendments, putting forward new ways of defining and measuring the headline indicator. His actions resulted in a politicisation of a simple governance object, in that he opened up the indicators to reveal conflicts and trade-offs inherent in a certain expression of energy efficiency indicators. In this sense, we can see the democratic mechanisms that allow alternative viewpoints to be exercised and incorporated into policy, dubbed 'little tools of democracy' (Asdal, 2008b), in EU parliament. However, the case study also reveals that the process through which the administrative tools and practices, political technologies, of the EU's Ordinary Legislative Procedure, have helped to produce controlled, objective and non-politicised energy efficiency indicators. These processes and practices eventually tamed Mr. Gierek's version of energy efficiency, through a subtle process of depoliticization through mundane bureaucratic practices and objects. The case study helped pinpoint different conceptualisations of energy efficiency, showing how they become unified through political processes of consensus-making and de-politicisation.

What does energy efficiency mean?

In general, most actors appear to assume that they mean the same thing when they talk about energy efficiency. The broad narrative that binds the concept together among actors is that energy efficiency means using energy less wastefully. It also means benefits for society in the forms of poverty alleviation, jobs and a better environment. The typically broad definition of energy efficiency that has been agreed on

[32] When the Commission produced its initial energy efficiency proposal, it used a discount rate of 10% to come up with its 30% binding target, judging it to be the most cost-effective option. However, an April 2018 study by the European Council for an Energy-Efficient Economy (ECEEE) insisted that 10% was too high compared to a member state average of just 5.7% for buildings.

since 2012 ('energy efficiency' means the ratio of output of performance, service, goods or energy, to input of energy) reflects this ambiguity. What is interesting in this case is that the politicisation of the object, through the intervention by Mr. Gierek, allows us to unpack what energy efficiency meant to different groups of policymakers. By examining the case of proposed changes and talking to informants, it was possible to tease out differences in meaning, principally between Mr. Gierek and the Commission, but also among other policy actors. Below is a table outlining these differences in the epistemic basis of different conceptualisations and what the various enactments of energy efficiency are that are attached to these meanings.

Table 1 Different enactments of energy efficiency among policymakers and institutions

Group/ Institution	**Preferred headline indicator**	**Narrative meaning/definition of energy efficiency**	**Enactment**
Commission	Primary and final energy consumption	Energy should be used in a more efficient way (i.e., less energy per unit of economic output)	A mixture of relative efficiency, where overall savings are not necessarily achieved, and absolute energy savings (Article 7).
Mr. Gierek and ITRE	Cumulated primary energy (including pre-conversion phase)	Energy efficiency is not about energy savings but about being efficient, especially energy generation and conversion processes	Relative efficiency, where overall savings are not necessarily achieved
Conservatives	Energy intensity	Energy efficiency does not mean savings	Relative efficiency, where overall savings are not necessarily achieved
S&D and Greens	Primary and final energy consumption	Energy savings, reducing/lowering energy consumption	Absolute energy savings

To Mr. Gierek, energy efficiency was more about the 'technical' ratio than energy savings. He focused on systems efficiency with the headline indicator expressed as cumulated primary energy. To some others, energy efficiency meant energy intensity, and not savings. Others however, wanted to focus on a reduction in energy consumption. What was being played out in parliamentary discussions was a common conflict and confusion over whether energy efficiency meant relative efficiency, where overall savings are not necessarily achieved, OR, whether it means a reduction in overall consumption and energy savings in and of itself, more akin to energy sufficiency or conservation principles. The differences in meaning

highlight the role of ambiguity in energy efficiency politics. According to political scientists, ambiguity is an essential ingredient to policymaking: "Ambiguity enables the transformation of individual intentions and actions into collective results and purposes. Without it, cooperation and compromise would be far more difficult, if not impossible" (Stone, 2012 pp. 178).

However, it is nevertheless important to analyse the underlying differences of opinion in meaning to energy efficiency, to understand what are various effects of policy implementation and different enactments of energy efficiency. By focusing on primary, rather than final energy, Mr. Gierek was enacting an energy efficiency that was distinct from that of the Commission – one that focused more on production, rather than consumption systems. While he argued that targeting primary energy would help to reduce energy losses and alleviate poverty by taking the burden off consumers to reduce energy at the final end of the chain, the Commission made the opposite argument that the best way to tackle energy poverty is to improve energy efficiency at the final energy consumption stage. Who is right? A pertinent query here is to what extent consumers would benefit from more targeted measures to improve energy efficiency on the supply side, where apparently significant savings can still be made. Comparatively richer EU countries may argue that there are few economic gains to be made in primary energy industries (supply side). But this cannot overlook the fact that richer nuclear-dominant countries advocate for measures that shift focus away from making nuclear energy generation more efficient. Nuclear is arguably inefficient when taking costs, slow construction times and nuclear waste into consideration. Despite its cons, nuclear gets favourable treatment when comparing its efficiency with other energy sources, in the form of the primary energy factor[33]. This special treatment puts into question the utility of applying the energy efficiency concept if indicators and measures are used to prop up wasteful and expensive industry. This issue is more relevant given the recent public outcry over the Commission decision to include nuclear on the list of 'sustainable investments' in its recently created EU taxonomy[34].

Thus, in this case, it is not necessarily energy efficiency that counts, but *how* energy savings are made that is important. This can be seen also in the case of Mr. Gierek's proposed methodology to measure energy efficiency. He was criticized for supporting coal because of his focus on generating innovation in primary

[33] The Primary Energy Factor (PEF) is the rate to which electricity is converted between different stages in the energy chain. It should reflect how much primary energy is used to generate a unit of final energy (e.g. electricity or thermal energy) through the use of consumption indicators. The current PEF for electricity that is prescribed within the European Union, as detailed in the Energy Efficiency Directive 27/2012/EU, is 2.5. That implies that each unit of electricity requires an input of 2.5 units of primary energy to produce it. So, for every unit of electricity consumed in our homes, 2.5 times more energy was needed to generate it. Therefore, the greater the difference between primary energy consumption and final energy consumption, the larger the implied losses throughout the energy system. For nuclear, this figure is placed at 3/1 which is more generous than conventional power stations which have a PEF ratio of 2.5.

[34] https://www.euractiv.com/section/energy-environment/news/investors-warn-green-label-for-gas-undermines-eu-taxonomy/

energy efficiency. Given the reliance of Poland on coal for citizen's livelihoods, it makes sense that Mr. Gierek would advocate for efficiency measures in coal. There are potential energy efficiency gains to be made in coal plants. However, this option was not politically desirable to others who saw the move as supporting the fossil fuels industry. Although coal may be a 'dirty' fuel, supporting it may arguably be sustaining Poland's energy poor. Thus, the question arises: how do we deal with energy inequalities – in terms of not only who is richer or poorer, but also who consumes more per capita, and how does their energy mix affect energy poverty? This is a familiar conundrum at the crux of global climate negotiations – who should bear the burden of emissions reductions? The answer is not simple and requires more than the current policy process to solve. More citizen involvement in policy would help to weigh up complex issues to do with values, identities, culture and inequality with regard to energy use. The public consultation showed that wider citizens' views played little part in the policymaking process. When taken as a whole, the case study shows that the way in which certain socio-economic systems in the relationship between end-users and industry are enacted is overwhelmingly dictated for, and by, industry interests, rather than decided upon by citizens and end consumers themselves. Scholars have made this point specifically for energy efficiency policy: that the inclusion of citizens in the design, implementation and learning processes around energy efficiency policies and interventions should be a policy priority (Foulds et al., 2020).

While the Commission's proposal focused largely on energy savings made at the end of the energy chain, it is largely consumers and taxpayers that foot the bill for many of these initiatives, unless funding comes from the public purse. Improvements, for example, include housing insulation, buying more efficient appliances and more transparent billing practices by energy companies. These strategies are seen as 'win-win' because they support growth in industry, for example in glass, insulation and electricity companies, while at the same time helping consumers save money from the energy they save. There still, however, exist perverse incentives that, for example, reward energy companies for the energy they sell rather than for cutting bills, that pay architects and engineers for what they spend, not what they save, and that put the burden for renovation on renters, rather than apartment or building owners. Furthermore, as the rebound effect literature shows (e.g. (Freire-gonzález, 2017), citizens may not necessarily be incentivized to reduce energy overall, but rather to use it at a more efficient rate, for example through more efficient appliances. A more nuanced policy to reduce energy use and energy poverty may be more effective in this regard, for example, policies that focus on absolute reduction in energy such as zero energy buildings (focusing on a mix of renewables, energy sufficiency, and energy efficiency) whereby buildings generate more energy than they consume (Saheb et al., 2018).

Technologies of politics and "thing-work"

Energy efficiency indicators were shaped through the bureaucratic practices and processes involved in the European legislative process. While Mr. Gierek's intervention politicised energy efficiency indicators, the legislative process itself had the reverse effect. It helped turn energy efficiency back into a non-political object, in that it was less controversial. The Commission's impact assessment was one material object that shaped the entire process. It was the favoured reference for policymakers to determine the how high or low the headline target should be set. Its appeal was that it broke policy choices down into crisp, clean and understandable scenarios measured in dollar terms, jobs and greenhouse gas emissions, thus acting as a useful tool to defer to when difficult and complex choices needed to be made. But different actors used the impact assessment findings for their own gain, to strengthen arguments both in favour of, or against, a higher or lower target. Crucially, the impact assessment appeared to help keep discussions centred on the target level rather than the methodology used to calculate it.

While the appeal of the impact assessment was its clarity and concreteness, on the flip side it tended to deal with complex issues in a fairly simplistic way. For example, regarding the rebound effect, the options were neatly presented with an explanation that the conservative figure (21%) was favoured over the conservative one (43%) because it was the figure stipulated in the most recent study. But this treatment of the issue, where cases of uncertainty can somehow be easily comparable and packaged into neat columns, belies the fact that, according to the literature, there is no consensus about the extent (and nature) of the rebound effect. A similar process of depoliticisation occurred when the Commission responded to a parliamentary question about the rebound effect with a typically cut-and-dried explanation of how the rebound effect was factored into modelling – with the response arriving too late for the parliament to take the answer into account in their conclusions.

The debates were in theory a place to openly discuss disagreements, however they became a place where the conversation was shut down and energy efficiency was turned back into a non-politicised governable object. Whenever points were raised about methodology, the conversation was swiftly turned back to the priority for parliamentarians as they saw it – reaching a consensus on the headline target. There was simply no more time nor space for such in-depth discussions. Mr. Gierek, on the other hand, had argued that the way energy efficiency was measured would have more effect on energy savings than the level of the targets – but his arguments were lost in the louder conversation that proceeded it about the headline target level.

Finally, the process of negotiation in favour of the Council during the trilogues meant that Member States had significantly more flexibility in whether to focus their progress towards the target on primary or final energy efficiency. This means, on the one hand, that Member states may choose to ignore the sectors precisely where Mr. Gierek wanted change in primary energy. On the other hand, according to the impact assessment, Member States could shift attention away from end-use consumption and "e.g. focus on a shift towards more renewable energies only, instead of aiming for energy efficient housing." (43, pp. 75) This latter example illustrates how energy efficiency and renewable energy objectives can conflict in practice[35]. To what extent is energy efficiency important if the main goal of policy is to decarbonise? For example, to avoid the complexities and policy challenges presented by Mr. Gierek's interpretation of efficiency and energy sources, primary energy consumption could be captured by the Emissions Trading System. This would also avoid uncomfortable tradeoffs of energy efficiency in disincentivizing decarbonisation by reducing the price on carbon in carbon trading.

4.7 Summary

Looking towards the future, what lies in store for energy efficiency policy? One way to re-politicize energy efficiency indicators is to openly discuss the tension between relative and absolute efficiency. Energy sufficiency principles have already gone some way to doing this, by being open about the subjectivities involved in placing absolute limits on energy consumption. For example, an emphasis is placed on better understanding what constitutes 'needs' and 'enough' in terms of consumption: are two cars per family too much? How much living space is enough? Is air conditioning set at 18 degrees Celsius necessary? Pertinent questions here are: who should be legitimately allowed to make such decisions? And what is the 'proper' level that such a policy should address? The next step would be to integrate sufficiency principles more into official statistics and indicators. Secondly, while the OLP has progressively been designed to make EU institutions more democratic, it still has a long way to go in terms of ensuring that alternative voices can be properly heard. This includes, citizens themselves and diverse stakeholder groups – who could help to further understand the societal and subjective aspects in energy efficiency indicators, rather than leaving these conversations up to experts and industry groups. After all, the inherently political nature of energy efficiency indicators means that because different actors are affected in different ways, everybody should have an understanding and a say in its outcomes.

[35] For example, in the energy efficiency legislation, renewables are given an artificially high PEF factor in order to incentivize their use. What this means is that renewables are considered 100% efficient when in fact they are often comparatively inefficient. Solar panels, for example, are comparatively inefficient to other technologies, at between approximately 20-25% efficiency (Svarc, 2022).

Chapter 5 - Discussion

At the start of this thesis, the question was asked whether the concept of energy efficiency itself needed a critical policy analysis. The answer to this is a resounding 'yes'. The dissertation has sought to not only investigate the criticisms made of the energy efficiency concept, but to go further to understand *why* and *how* some of these problems occur in the first place. These criticisms include: the concept is narrow in that it misses out important aspects of energy conversion processes and sociological aspects, that it is not effective in its goal to reduce energy consumption, and that it obfuscates tradeoffs and externalities. The dissertation has gone beyond merely clarifying these criticisms, to explore how the concept of energy efficiency is co-produced with certain scientific, normative and institutional-organizational orderings, and what are the consequences of these. It has done this by disentangling the concept, right from its historical foundations up to the present day, to better understand what values and interests are embedded and interwoven with the concept and its use.

Reviewing the concept of energy efficiency in this way is problematic, however, because raises an important question: is the concept of energy efficiency the problem, or does the problem stem from the governance framework that surrounds the concept? Does the way the concept is formulated and quantified have a performative effect on the way we see the world, and thus how policy is designed and implemented with relation to the concept of energy efficiency, or is it the other way around, that the governance context shapes the concept of energy efficiency? While it may not be possible to answer this question in a simple way, it is clear that the concept cannot be separated from the policy and scientific context within which it is situated, and therefore a discussion about both, analysed together, is included below.

Theories from Critical Policy Studies and STS and were utilized to understand how energy efficiency is governed and to pinpoint what tradeoffs exist in the application of the energy efficiency. Specifically, discourse analysis was employed to study elements of meaning and argumentation in policy, as well as critical issues to do with power, political motives and policy outcomes. Insights from research on politics of indicators helped to reveal disputes in energy efficiency policy that were being played out in arguments over how energy efficiency was defined and how indicators were calculated. The end goal of the research is to highlight where value judgements, conflicts and tradeoffs lie in energy efficiency policy in order to better identify and take into account these weaknesses in policy. The expectation is that, by highlighting these issues, EU energy efficiency policy can be made more sustainable and robust long term, more

effective in its aims to reduce overall energy consumption and GHG emissions, and properly address and include citizen's needs and community priorities. The thesis is structured in 3 main sections which can be summarized as 1) a conceptual literature review 2) a historical discourse analysis of energy efficiency policy and 3) a contemporary case study of energy efficiency policymaking process.

5.1 What does energy efficiency mean, and why is this important?

The findings of this research illustrate that the concept can mean different things to different people, depending on how it is defined and applied. Further, energy efficiency is a concept that is constantly in-the-making, and it is made differently in different sites. Thus, when it comes to energy efficiency, context is crucial. For example, observing energy efficiency in a historical context shows how policy priorities and historical events are reflected in the way energy efficiency is defined and applied in each decade. This includes during the nuclear era, when energy efficiency played a minor role, which contrasted starkly to the later 'no-waste' approach of energy efficiency and conservation policies that became popular later on in energy efficiency policy. Energy efficiency changed again during the 1980s to take on a stronger economic mantle as the priorities of free markets and capitalist expansion came to the fore.

The energy efficiency literature is a multitude of conceptualisations of energy efficiency, including a dominant view that tends to assume that challenges encountered in its application are caused by certain economic, behavioural or institutional 'barriers' rather than conceptual, political or cultural opportunities and constraints. Another major body of knowledge is methodological, that reveals the significant challenges in applying the concept of energy efficiency in the material world, including the epistemological conundrum of value judgements. The sociological research on energy efficiency often tends to critique the concept of energy efficiency itself, including how it has become abstracted from the real world, and how economic interests to save money dominate the field and policy directives. A key research gap identified in the literature review is that of value judgements – a point of overlap between the SSH literature and methodological literature that seeks to better understand the challenges regarding the 'output' of an energy efficiency ratio, which incorporates subjective value judgements. It can be seen as a conceptual bridge between the more 'technical' quantitative methodological challenges, and the more sociological based conceptual challenges identified in the energy efficiency literature. Therefore, this thesis has not only used SSH insights, but has applied them together with the more 'hard' sciences perspective, in particular, the quantitative aspects of energy efficiency definitions and indicators.

This dissertation highlights the place of ambiguity in energy efficiency politics. In Chapter 4, the contemporary political case study, most actors appear to assume that they mean the same thing when they talk about energy efficiency. The broad narrative that binds the concept together among actors is that energy efficiency means using energy less wastefully. A behaviouralist framing is reinforced through this narrative, leaving little space for it to be challenged. The implication is that energy efficiency is good and everybody must use energy sparingly, in an efficient manner, compared with being energy inefficient, which is 'bad'. This normative characterization of energy efficiency as a 'good' in and of itself is reflected in the findings of the literature review and discourse analysis that align energy efficiency with virtues of prudence and rationality. The broad narrative of energy efficiency means benefits for society in the forms of poverty alleviation, jobs and a better environment. The typically broad and generic definition of energy efficiency, agreed since 2012 in EU policy, ('energy efficiency' means the ratio of output of performance, service, goods or energy, to input of energy) reflects this ambiguity. As a characteristically ambiguous term then, energy efficiency is a 'motherhood concept', like efficiency more generally. It is similarly seen as a 'win-win' situation, in that energy efficiency can do many things at the same time, including reducing energy consumption and thus pollution whilst also saving money. For this reason, it is an effective policy tool for helping to form consensus, because it is easy to gain broad support for energy efficiency policy when conceptualized as a 'win-win' policy.

This research however, shows that when the concept is broken down, different political actors have different, often conflicting, ideas about what energy efficiency is. In Chapter 4, the contemporary political study, some actors viewed energy efficiency as energy intensity, that is, as an economic measure, while others aligned it with energy savings, as a strategy to limit overall energy consumption. Others rejected this definition to focus less on absolute energy consumption reduction and more on an efficient rate (i.e., ratio) of relative efficiency. What is the problem, then, if different actors have different ideas of what energy efficiency is while broadly agreeing to a definition that facilitates forming a consensus? In the case set out in Chapter 4, there appeared to be a lack of understanding of the positions of others, and there was a lack of understanding of the more complex aspects of energy efficiency in many of the situations described, including for example of the rebound effect and how the PEF factor works. According to Stone (2012), it is important for policy analysts to understand and clarify underlying differences of opinion and conflict when analysing 'motherhood issues' to avoid myopia, and to help policymakers come to a consensus once the points of contention are properly understood. According to Franco and Jorizzo (2019) and Goh and Ang (2020), confusion over what energy efficiency means can hamper the effectiveness of policy designed to reduce consumption, given a lack of specificity about policy actions and targets for absolute energy consumption limits. It is clear, however, that ambiguity cannot be solely seen as a

negative, as a significant degree of policymaking is being able to reach compromise, and ambiguity plays a role in this (Stone, 2012). The importance of the findings from this research, however, is that tradeoffs and political disagreements relating to how energy efficiency measures are implemented in policy appear to be rendered invisible through seemingly apolitical indicators and quantitative measures – methodologies which follow their own language that only a select group of researchers and experts understand. This is important, because actors involved in policy, including citizens themselves, may not understand the implications of the way energy efficiency is measured for them and their constituents.

5.2 Thinking about ends rather than means

This conundrum in the previous section about political aspects of energy efficiency being rendered invisible through quantitative indicators feeds into one of the major findings of this research - that focus is being increasingly placed on energy efficiency targets, rather than the way that energy efficiency and targets are being measured themselves. The two issues are related because if the focus is more on the abstract target rather than the methodology, then less focus is placed on the nitty gritty details and political aspects that are ingrained in quantitative representations of energy efficiency. For example, in Chapter 3 we can see that, over time, more attention was being paid to the headline 'energy efficiency' targets while less attention was paid to the methodologies of the targets. As this happened, the values and tradeoffs inherent in the application of the concept became less visible. This can be considered as a type of depoliticisation, as the 'political' elements of energy efficiency are hidden. As depolitisation escalates, there is less inclusion of affected others and less diversity of opinion and perspectives, which are important for robust and fit-for-purpose policy that considers all those affected by a policy decision. A related process was observed in Chapter 4, the political case study, whereby the administrative and policy procedures tended to focus less on the methodology and more on finding consensus on the headline target in an expeditious manner. Mr. Gierek's actions, in contesting the status quo of the way energy efficiency was defined and measured, opened up the indicators themselves to reveal the conflicts and trade-offs inherent in a certain expression of energy efficiency indicators, that had hitherto been rendered invisible. This pattern of ends rather than means thinking can be connected with the sentiment made by sociologists studying efficiency more generally, in that efficiency does not focus enough on what is actually being measured, but too much on the fact that 'something' is being done more efficiently, and that must be a good thing.

In the case of energy efficiency, then, why is it so important that more attention is being given to the methodologies rather than the target or end goal itself? Paying attention to the methodology is important because it plays a large part in determining the effectiveness of policy and whether or not it meets its intended outcomes. Firstly, the headline target has become so abstract that loopholes can be found to reduce the obligation of European countries to reduce their energy consumption. For example, the and/or wording change during the 2018 amendments to the Energy Efficiency Directive meant that countries could choose whether they wanted to reduce primary or final energy, and not both, so they can omit certain industries from their measures. This means that countries may be making less savings than would otherwise have been the case.

Further, the case study showed the importance of taking into consideration the energy source – it matters whether energy efficiency gains are made in coal, or nuclear, or renewable energy, because this choice factors in issues that fall outside the remit of the energy efficiency ratio, including carbon and other pollution emissions, cost and convenience. Focusing on the way energy efficiency is measured also affects problems like pollution displacement. The measure of primary energy, for example, does not look at the efficiency of the energy resource before it reaches Europe's borders, which means we may be propounding pollution and inefficiency in energy exporter countries.

5.3 Energy efficiency as a governance object

What we can conclude from this research is that it is crucial to understand the energy efficiency concept and its quantification as a political process, not just a scientific one, and particularly as a governance object that can be shaped and defined by different stakeholders, depending on their interests and constituencies. Different industries and actors are set to benefit or lose out depending on what the focus is of the headline target regarding measurement. These include, for example, actors along the energy chain (i.e., in generation, transmission, and the final consumer), the energy type (i.e., fossil fuels, such as coal, renewables, such as solar or nuclear) and, finally, people in different geographies (i.e., different Member States). Energy efficiency and its measurement indicators are not value neutral. Powerful interests actively influence the definition of energy efficiency and energy efficiency indicators for their own gain. The case study in Chapter 4 shows how the way that energy efficiency is quantified impacts on different member states, depending on their energy sources and relative power and wealth. For example, many poorer EU nations were against taking more stringent energy efficiency measures based on cost, because of the cost implications for their budgets. Some comparatively richer EU countries, especially those with

nuclear-dominant energy industries, were more in favour of measures targeting the final end of the energy chain. This is because such measures are likely, in part, to shift a focus away from measuring what makes energy generation more efficient. Nuclear is arguably inefficient when considering costs, slow in construction times and nuclear waste. Despite its disadvantages, nuclear receives favourable treatment when comparing its levels of efficiency with other energy sources, in the form of the primary energy factor[36]. In contrast, some politicians such as Mr. Gierek, argued that there should be more focus on making the production and generation of energy more efficient because that is where most gains are to be made. This focus could benefit his country, Poland, by making the process of coal generation more efficient. Thus, in terms of insights coming from this thesis, it is critical to understand *how* energy efficiency gains are being made (i.e., from which energy source) and *who* would benefit from these gains.

Equality and fairness have, thus, become major themes in energy efficiency politics. This includes many wider issues concerned with matters such as: who bears the burden of improving energy efficiency and reducing greenhouse gas emissions, and how this should be done? For example, a clash in opinion on how energy efficiency should be expressed had implications for who bears the burden of energy savings and centred on the debate about whether a focus on the final end of the energy chain, or at the primary energy (initial, input) stage, would better alleviate poverty. Mr. Gierek argued that targeting primary energy would significantly reduce energy losses and take the burden off consumers to reduce energy at the final (consumption, output) end of the chain, thus alleviating energy poverty. The Commission, however, makes a contrasting argument, that is, that the best way to alleviate energy poverty is to focus on improving energy efficiency at the final energy consumption stage. This preference could involve a conflict of interest, however, as industries at the final end of the energy chain, including insulation, glass and energy efficiency technicians and product providers, could benefit from a focus on the final consumer stage. The purview of this study was not to determine who was 'right' or 'wrong'. Rather, what was crucial is highlighting the detail of the debates to cut through the political rhetoric and ensure that policy is effective in carrying out its intended aims – in this case to solve the crisis of energy poverty in Europe.

[36] The Primary Energy Factor (PEF) is the rate to which electricity is converted between different stages in the energy chain. It should reflect how much primary energy is used to generate a unit of final energy (e.g. electricity or thermal energy) through the use of consumption indicators. The current PEF for electricity that is prescribed within the European Union, as detailed in the Energy Efficiency Directive 27/2012/EU, is 2.5. That implies that each unit of electricity requires an input of 2.5 units of primary energy to produce it. So, for every unit of electricity consumed in our homes, 2.5 times more energy was needed to generate it. Therefore, the greater the difference between primary energy consumption and final energy consumption, the larger the implied losses throughout the energy system. For nuclear, this figure is placed at 3/1 which is more generous than conventional power stations which have a PEF ratio of 2.5.

5.4 What is missing in energy efficiency policy?

Scientists, practitioners, industry, and policymakers alike tend to frame energy efficiency by including some elements and omitting others. All the main chapters of this dissertation have pinpointed those aspects that the concept of energy efficiency tends not to cover. Looking at the energy efficiency literature, Chapter 2 found that sociological frames, such as ethics, equality, justice concerns, philosophy, and history were lacking in many studies and called for more comprehensive and balanced research. The literature review found that questions, such as 'How did the concept of energy efficiency emerge and why?', and 'How has the concept changed over time?', had not been comprehensively answered. It also found that tradeoffs in the way that the concept of energy efficiency is applied to the physical, material world are still not fully understood, and there is a considerable gap in this area of research. The historical analysis in Chapter 3 aimed to address these questions by analysing energy efficiency policy historically and chronologically. It found that the concept varied considerably over seven decades. The historical discourse analysis of EU policy found particular social and environmental tradeoffs in the way that energy efficiency policy is designed and implemented and how potentially relevant concepts and issues get sidelined in favour of others. Examples in each decade show how cost considerations are prioritized over environmental and social concerns, both in the language used and in the specific policy actions outlined. The economic focus becomes stronger in the 1980s, with 'the market' featuring prominently in EU energy efficiency policy in later decades. This gradually narrows into the 'energy efficiency market'. A shift towards a 'market transformation' globally is strongly represented in the language relating to 'market barriers' that are claimed to impede the realization of the full potential of energy efficiency. The case study of EU politics also revealed a discursive divide in-between political actors who wanted cheaper policy, versus those who wanted tougher environmental action.

When analysing all chapters, an important revelation is that the political rhetoric has changed with regards to tradeoffs inherent between environmental interests on the one hand, and energy and industry interests on the other. At one point in the 1970s, differing interests were acknowledged and made explicit between environmental advocates on the one hand, and energy industry interests on the other in EU policy Eventually, however, by the 1980s, the language had changed. Instead, these differing interests were not acknowledged. Instead, energy efficiency was sold as a 'win-win' for all sides. The element that was used to harmonise environmental and economic interests within the concept of energy efficiency was technology. Technological innovation became the magic word that brought opposing sides together conceptually, especially that of renewable technology, seen as something both environmentally and cost

friendly. This finding shows how important it is to made visible these conflicts and tradeoffs to understand the effect that policy implementation will have on different actors, society, industry and the environment.

Chapter 3 identified how energy efficiency has been as an effective rhetorical device in its claims of a 'free lunch', promising something for nothing. In this way, energy efficiency is depicted as a more appealing option than strategies to reduce energy that involve a restraint on demand and sacrifice on the consumer's part. For example, through the discourse analysis, the documents of the 1970s imply that there is no loss of comfort or convenience on the consumer's part in using less energy for the same level of output. Energy efficiency is also found to be used as a 'stealth metaphor', offering perpetual energy but false promises. When energy efficiency is characterized as 'an energy source in its own right', it makes something that never actually existed – energy that hasn't been used – as valuable as tangible oil, gas or solar energy. The rhetoric of energy efficiency can be compared to that of the nuclear era fuel metaphor that claimed it was the 'cheap fuel that never runs out' or that nuclear-produced electricity would be "too cheap to meter". Both depictions have an ethereal tone, as if energy efficiency and nuclear are perpetual energy machines or fountains of youth. But as we have seen, these metaphors are problematic because free lunches are never actually free. Energy efficiency policy may not be as effective as expected in reducing energy demand, requiring hefty investment that is either monetary, time-related or labour intensive. Treating all energy sources as one and the same thing is misleading – using any given energy source has relative advantages and disadvantages (e.g., cost, location, carbon content). Thus, it does not make sense to conflate them.

The discourse analysis found that the conceptualisation of energy efficiency was increasingly linked to a wide range of outputs and benefits, which also acted as a 'free' promise. The theme of 'energy efficiency benefits' is dominant in both the conceptual literature review and the historical discourse analysis. In the literature review, the 'energy efficiency benefits' line of research was geared towards technical and economic perspectives, and was found to be normative in assuming that energy efficiency is an inherent good and therefore a preferred strategy by which to achieve multiple benefits. In the discourse analysis, the increasingly longer list of benefits was found to be an effective rhetorical device as energy efficiency is depicted as a panacea for many of the EU's problems. In the 1980s, energy efficiency societal benefits; the texts states that energy efficiency measures would create new jobs and industrial activity, and would support environmental aims. In the 1990s, energy efficiency improvements would supposedly bring stronger economic and social cohesion to the European Community. In the 2000s, the promise is largely one of economic growth. These promises had dramatically increased by 2018, when it is claimed that

energy efficiency improvements will lead to such benefits as improved air quality, reduced greenhouse gas emissions, improved energy security, cuts to energy costs for households and companies, alleviation of energy poverty, increased competitiveness and economic activity, and more jobs and improvements for citizens' quality of life (European Parliament and Council of the European Union, 2018: 210).
The dominant, normative assumption that energy efficiency is a panacea for Europe's problems in both the literature and in policy overlooks the fact that there is significant doubt also expressed in the literature about the extent of benefits and energy efficiency gaps, and whether benefits can actually be realised. This includes the extent of additionality of energy efficiency improvements, such as reduced energy consumption, reduced emissions, and reducing energy poverty, which are difficult to demonstrate empirically. This conundrum leaves us in the realm of complexity and uncertainty, and begs the question: if we cannot demonstrate benefits with certainty using current scientific methods, what methods do we need to employ to address this uncertainty? This is an area of research that would shift energy efficiency science and policy to more adequately address problems to do with the rebound effect and ascertaining additionality of energy efficiency actions.

One approach could be to focus more on modes of governance. Rip (2006) proposed the concept of governance in complexity. This concept seeks to go beyond standard models of governance based on technocratic paradigms founded on predictability and control (i.e., governance of complexity), but proposing a governance that openly accepts complexity and uncertainty without trying to control or predict it. That is, governance that embraces uncertainty in that it is part and parcel of science and policymaking rather than something that can be 'fixed' through more research. This mode of governance "invites a different relationship between science and policy that moves away from apparent consensus and is open to criticism of ideas" (Kovacic et al., 2021, pp.12). Such a form of governance in the case of energy efficiency would mean embracing uncertainties, such as the rebound effect and the reason that energy consumption is rising or falling, without trying to predict why and how. It would mean acknowledging the rebound effect in the public arena, rather than exclusively confining it to the energy efficiency literature and high-level discussions. Governance in complexity would also mean focusing more on local projects and interventions, specifically adapted to a local context, rather than aiming to make ambitious interventions at the wider EU level.

Some authors, including Dryzek (2013), argue that the bureaucratic structure of administrative rationalism, as portrayed by the EU and its institutions, is not equipped to properly manage complex problems because it implies hierarchy based on expertise, with both power and knowledge centralized at the apex. This structure is unsuitable in this instance, because complex problems, which involve a large

number and variety of elements and interactions facing a decision system, cannot be intelligently disaggregated. The result then, in Administrative Rationalism, is problem displacement rather than effective problem solving. Another result of bureaucracy that is ineffective at lower levels of governance is what's known as the 'implementation deficit' (Weale, 1991): a substantial gap between what legislation and high-level executive decisions declare will be achieved and what is actually achieved at street level. In order to counter these problems, Dryzek suggests more focus on *governance* than government, that is more on decentralized, informal and networked institutions.

A question not answered through these governance scenarios, however, is what should be done about tradeoffs, once they are made visible? Is there an effective way to bring opposing sides together to come to some sort of harmonious policy solution? How does one balance the act between different equally legitimate values and policy goals? This research does not yet hold the answers to this dilemma, suffice to say that perhaps nobody has the perfect answer yet. The best solution remains to surface the conflicts, tease them apart, and hope to find common ground and compromise. An idea could be to address these conflicts through co-creation mechanisms where citizens have a greater say in policy. For example, deliberative methods such as citizens' assemblies and citizens' juries have been successful in finding consensus on controversial issues. The citizens' assembly in Ireland called 'We the Citizens', through deliberation, came to a citizen consensus on abortion policy, which was then signed into law through a wider referendum.

5.5 The future of energy efficiency – a limited concept needing reformulation

Energy efficiency is a popular energy and environmental policy concept. But given the multitude of problems outlined above, including its challenging political contradictions, what should be done with the concept of energy efficiency? It is clear that the status quo and the way that the concept is being applied contemporarily in its current form is not enough to help reduce energy consumption and GHGs and to solve current complex problems. The energy efficiency concept and, in turn, the way it is applied in policy, has become so dominant that we risk being locked into simplistic methods – that of the input/output ratio – rather than considering and applying more effective and nuanced policies that are better suited to our complex energy system and society. The normative characteristic of energy efficiency as a ratio may mean that we only see energy use as just that – relative, rather than absolute, efficiency – and forget alternative solutions, such as sufficiency, that are more difficult to fit into the quantitative ratio mold.

Furthermore, one can infer from this research that the quantitative representation of energy efficiency is being increasingly rendered meaningless in policy. This is especially so given the fact that more focus is being directed towards consumer behaviour to use less energy services and reduce energy demand, both of which align with conservation and sufficiency efforts than with the energy efficiency ratio. This shift, however, contrasts with the traditional neoclassical economics objective of energy efficiency, which assumes that more energy services are better. What's more, the ratio of systems efficiency as part of the headline target was weakened in 2018 when the obligation to lower *both* primary energy *and* final energy consumption was removed. Thus, one could argue that the energy efficiency input/output ratio is less important to policy than it was before, and that it is rendered somewhat meaningless as a result. Given this waning quantitative focus on the energy efficiency ratio in energy efficiency legislation, then, one must wonder why the legislation isn't called the energy savings or energy conservation directive. The answer to this question, some argue, is that 'energy efficiency' is just too seductive to let go (Brookes, 2000; Moezzi, 2000). We have seen that it an extremely popular strategy and policy objective across industry, the public sector, and society. It therefore may not make practical nor political sense to do away with the concept of energy efficiency entirely. The popularity of energy efficiency is an advantage. It therefore makes sense to either mold the concept into something that is more effective in achieving its aims, or apply it in tandem with a concept that can be more effective – and meet the needs of citizens, rather than the interests big business and policymakers only.

But where is the causal lever to mold it into something else, or apply it with a complimentary strategy? A large part of this solution would need to come from the 'energy efficiency industry' itself, as well as from policymakers and, importantly, from citizens. Is this outcome probable, or even possible? The dominant conceptualisation and discourse of energy efficiency is very strong and has remained so for the last few decades. What is the likelihood, then, that one techno-managerial concept (efficiency) is replaced with another (sufficiency) when the institutional-organizational and political configurations through which the former (efficiency) gained its meaning originally remain the same? On the one hand, it could be argued that it is unlikely that change will occur without changing the extant institutional-organisational and political configurations as referred to above. In order for policymakers, industry and society to take resource and environmental constraints seriously, it may only take a major upheaval, such as power cuts, blackouts, and/or severe natural disasters caused by global warming. This has happened in the times of severe energy conservation efforts during the oil crises and Japanese Fukushima nuclear disaster, but has typically been a temporary change.

In outlining this proposition, however, this thesis demonstrates just how fluid and changeable the concept of energy efficiency can be. The historical discourse analysis in Chapter 3 showed how, depending on societal, political and industrial priorities at the time, energy efficiency policy has shown to be progressive. For example, energy poverty considerations were first added to the 2018 amended directive, and the most recent (at time of writing) proposal in 2021 for a recast of the energy efficiency directive (European Commission, 2021) announces plans for more social support through the EED and 'Fit for 55 Package'. This proposal contains a funding instrument based on the revenues from the new Emissions Trading Scheme (ETS) to mitigate the impact of higher costs for consumers as a result of the introduction of a carbon price in the road transport and building sectors. The proposal states that the funding instrument would help protect from these effects vulnerable energy customers, households affected by, or at risk of, energy poverty, and people living in social housing. Further, the Social Climate Fund is planned to provide funding to Member States to support their measures and investments intended to increase the energy efficiency of buildings, to carry out energy efficiency improvements, building renovation, and to decarbonise heating and cooling of buildings, including the integration of energy production from renewable energy sources, and to finance zero- and low- emission mobility. This reform could be a consequence of institutional-organisational and political change in the EU. The Von der Leyen Commission has strengthened the Commission's commitment to tackling climate change, while progressive groups including The Greens party gained their vote in EU Parliamentary elections in 2019.

As for molding the concept of energy efficiency into, or using it in parallel with, policy that takes into account overall consumption limits, this change has already begun, albeit on a small scale. For over a decade, academics and environmentalists, and, now, an increasing number of policymakers and NGOs, are calling for more focus on the concept of sufficiency, which implies a reduction in output. The difference between the two concepts, efficiency and sufficiency, is that energy efficiency reduces energy input while keeping the utility/services from energy constant. On the other hand, with sufficiency, energy consumption is reduced while the utility/technical service changes in quantity or quality (Princen, 2005; Thomas et al., 2015). Sufficiency doesn't necessarily expect technology to reduce energy consumption; rather it seeks out community solutions and changes in energy consumption practices that reduce energy consumption overall: for example, by opting to invest more in public transport and carsharing than more efficient cars for each family. This perspective mirrors Stone's (2012) point that community and collaborative approaches that reflect societal dynamics are needed for meaningful policy outcomes, not a narrow market focus. Indicators need to encourage consumption limits, including sufficiency principles. These include measures in cubic feet to disincentivize large living spaces, more sustainable transport

options, such as public transport, and alternative options for everyday living (e.g., drying clothes outside rather than in the dryer, and washing dishes by hand rather than using the dishwasher).

Energy efficiency and sufficiency are not necessarily incompatible. In fact, they can be complementary as policy tools. Areas where the two concepts overlap include energy taxation, progressive energy prices, and standards based on absolute consumption. However, sufficiency takes a different approach in other areas. An important part of sufficiency is to properly understand and mitigate drivers of unsustainable energy consumption, including capitalist production logics, such as rapid innovation cycles and short product lifetimes, cultural norms for energy consumption (e.g. lower air conditioning temperatures and increasing tv-screen sizes). It focuses on alternative energy consumption practices that may involve less 'comfort' or less time-saving for the consumer – such as drying clothes in the sun or putting limits on average dwelling floor area per person. However, ideas of 'comfort', or what levels of energy consumption are 'enough', are subjective and depend not only on individual and group culture and preferences changing, but also a reconfiguration of powerful industry interests that have a strong incentive to make profits by selling more and bigger appliances. This is a challenging part of implementing sufficiency principles as subjective norms come into play (Darby, 2007). For example, how many cars in one family is enough? None, one, two or more? Should the floor surface area of houses be restricted? Is air conditioning set at 18 degrees Celsius necessary? Coming to agreement on such topics will be a challenge going forward, with the need for better understandings of how to engage citizens in the quest for sufficiency and solve the challenge of how to define and understand needs, desires, and norms of energy use (e.g. Vadovics and Živčič, 2019). Nevertheless, openly discussing the subjectivities involved in placing absolute limits on energy consumption is a way to make visible the politics of energy efficiency measurement and related indicators. This, in turn, allows a collective effort to better tackle the uncomfortable issues involved in energy consumption reduction. The concept of 'uncomfortable knowledge' (Rayner, 2012) is apt here, because 'uncomfortable knowledge' refers to the knowledge that contradicts or is in tension with simplified and easy-to-understand versions of the world that help individuals make sense of it. Importantly, this 'uncomfortable knowledge' must not be omitted from policy debates, especially when dealing with wicked issues such as energy consumption reduction and climate change, because it is essential to understand, and properly address, the problem. Another major challenge that faces the alternative conceptualisation of sufficiency is that it does not befall the fate of its similar predecessors, including energy conservation – that is, that it doesn't becomes unpopular because it is associated with pain and sacrifice. Instead, proponents may try to align more positive connotations with the idea of absolute consumption limits by appealing to ideas of living better with less and supporting sustainable, community-driven reform (see, for example, D'Alisa et al., 2014).

A crucial part of these 'uncomfortable knowledge' (Rayner, 2012) conversations and decisions should be greater citizen and stakeholder input in policy, as mentioned earlier. The inclusion of a diversity of citizens and energy consumers within the policy process could make these processes fairer and sustainable – especially if citizens were included in the process to evaluate the metrics with which we use to quantify energy efficiency and energy sufficiency. A number of pilot projects, including, e.g., the Energise Project[37], have successfully exceeded the limited conceptualisations of individual behaviour, working with citizens to change their daily practices at a small scale to save more energy and choose sustainable actions. Such projects are not so much about telling people what to do or providing information through a one-way channel, but rather engaging consumers face-to-face to understand what citizens' ideas of 'enough' are, supporting them in developing their own ideas for energy reduction, and guiding them as to how this can be done in practice. It would be beneficial in the long term if citizens and the wider community were given accurate and clear information about phenomena, such as the rebound effect, and the difference between overall and relative consumption, so that they can make more informed choices regarding how they use and consume energy.

That being said, however, the responsibility to reduce energy consumption should not be placed squarely on citizens. Current energy efficiency policy is dictated by powerful industry and political interests. This power imbalance needs greater regulation and transparency to keep monopolistic energy interests accountable. While this research has gone some way to reveal some of these insights, there is much more work to be done in the field of energy efficiency to understand the networks and energy regimes that makes up the 'Energy Efficiency Industry', and whose interests are being favoured, and why. Another major research theme that needs further attention is *who* should be burdened with energy savings obligations. Should there should be more focus placed on making energy efficiency improvements during the upstream processes of, for example, energy generation, conversion, transmission and transportation, or more place at the final consumer end? Who gets to decide this? The formulation of energy efficiency policy would be improved if those in the policymaking process have a better grasp of these issues, and also who are able to balance the challenges involved in bringing together both the 'technical' and methodological engineering aspects of energy efficiency and the sociological aspects.

[37] https://www.energise-project.eu/

Chapter 6 - Conclusions

This thesis suggests that 'Not all that glitters is gold – A critical policy analysis of energy efficiency'. It demonstrates, first and foremost, that energy efficiency is not the panacea for our energy problems that many believe it to be. By seeking to critically examine the concept itself, through a social sciences lens, the thesis has revealed the ontological ambiguities and has dismantled the tradeoffs inherent in the concept, which are problematic from both a practical and a theoretical point of view.

A key insight arising from this thesis is that, while the chameleon-like concept of energy efficiency is becoming increasingly complex over time, a depoliticisation through weakened political processes is rendering these problematic social and environmental tradeoffs as invisible. Furthermore, while advocates of energy efficiency strategies have repeatedly promised a 'free lunch' of benefits, these are rarely 'free'. These alluring offers must be critically examined, especially given the practical difficulties is proving additionality of energy efficiency actions and complexity in measuring and connecting these benefits to energy efficiency actions. When observing the production of energy efficiency indicators, it is crucial to understand the hidden interests behind decisions made. This is because the effectiveness of policy depends on whose interests its serves, whether industry actors, policymakers, or citizens themselves.

The energy efficiency concept needs to advance beyond being seen as a good in and of itself, and the false notion that more equals better. It needs to be shaped in such a way that can meet the challenges of today's complex world, including limiting resource use to stay within the earth's planetary boundaries. One way this can occur is to reconceptualize energy efficiency as sufficiency – a concept that is gaining traction in academia and civil society. The concept of sufficiency enables open conversations about how much is 'enough' in energy consumed – something that energy efficiency cannot address in its perpetuation of the status quo view that more energy services mean 'better'. Many actors in the policy arena already appear to be shedding elements of the input/output concept of energy efficiency in favour of actions that work to better understand consumption systems and social practices. Such moves need to go so much further than simplistic economics/behavioural perspectives to define energy practices themselves, including gaining sociological insights into the people and societies who consume energy. Together with improved governance systems, citizen participation, and collective solutions, more long term and sustainable solutions to the energy crisis need to be championed and turned into something that more closely resembles gold.

Chapter 7 – Bibliography

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