Reorienting finance towards energy efficiency in the UK

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Abstract

This paper examines the challenges associated with stimulating large-scale investment in energy efficiency and demand management measures. We focus on institutional changes necessary for mainstream financial institutions, such as pension funds and insurance companies, to seriously address efficiency and demand side issues. This draws on recent literature on green finance to examine the role of financial institutions in transforming energy systems. Recent policy-oriented research has proposed framing energy efficiency as a core part of infrastructure investment. This could enable appraising multiple social and environmental benefits of energy efficiency, and overcoming accounting rules which hinder fair treatment of energy efficiency investments. We explore how this could be applied in the UK context to fill the policy vacuum left by the failure of the Green Deal. We examine the potential for this to deliver comparable benefits to other major infrastructure investments, with the added benefit of reducing supply-side investment needs and thereby the risk of stranded assets.

However, this type of reorientation of energy efficiency policies would require commitment from the mainstream investment community, which faces structural as well as behavioural constraints on investing in low carbon options. We examine the roles of potential funding vehicles including the Green Investment Bank and green bonds, learn from a large scale publicly funded domestic energy efficiency project, and consider new proposed models, such as revolving funds financed by private investment. We draw interim conclusions and outline how future research will draw on interviews with members of the investment community, in order to examine what further measures may be needed to overcome structural and behavioural constraints to large-scale investment in energy efficiency and demand management measures.

Introduction

The global question of sustainable development has in recent years shone a light on the question of finance. The United Nations Environment Programme (UNEP) reports on aligning the global financial system with sustainable development goals (UNEP 2015), suggesting there is a need to harness the full potential of the financial system in order to deliver a transition to sustainable development. This includes 'harnessing the public balance sheet' through measures such as fiscal incentives for investors, combining public and private finance, and more. Further, there is growing recognition that the finance system needs to be shaped to be better connected to the real economy. The Global Commission on the Economy and Climate state that the financial system has to be transformed if it is to deliver the scale and quality of investment needed in order to 'green' the system (New Climate Economy 2016), including significant investments in energy efficiency in buildings, energy and transportation. Another perspective is that large financial institutions are enablers in energy transitions (Hall et al. 2016), making their role vital in the pursuit of a global shift to a low carbon energy system.

A related challenge is that the global financial system is unstable with long-term issues like sustainability sidelined due to excessive leverage and short-termism (UNEP 2015). The increasing short-termism in finance means venture capital (private finance invested in early stage firms, with high risk but potentially high rewards) can only play a limited role in this transition, but given the huge investment required, public investment cannot bridge the gap on its own (Mazzucato & Perez 2015). Overall, there is widespread agreement that financing sustainable development requires reorienting the finance system, including redirecting capital flows towards 'critical priorities' and away from 'assets that deplete natural capital', i.e. the stock of natural resources (UNEP 2015). However, there may now be an historic window of opportunity to develop a more sustainable system, following the global financial crisis and the stronger calls for sustainable development and international agreement on combating climate change. Among other things, changes in the finance system, including new financial models and tools, are needed to achieve a sustainable green transformation (Naidoo, 2016).

The degree of change needed to the financial system, and the wider economy, is itself a matter of debate. In the UK (and elsewhere), there are suggestions that decarbonising the economy is an opportunity for economic growth (Carney 2016; Blackrock 2016; Holmes & Mabey 2009). Some reports conservatively suggest that investors can gradually introduce climate change considerations into their portfolios, as "Climate-aware investing is possible without compromising on traditional goals of maximizing investment returns" (Blackrock 2016), or that the UK government should focus on maximising opportunities in the global transition from high to low carbon economies by creating a 'level playing field' (Amon & Holmes 2016) where energy efficiency and demand response can compete with the supply side (Holmes & Mabey 2009). However, Mazzucato and Perez (2015) argue that the challenge is not merely to 'fix' the finance system, but to change the real economy to allow inclusive, green growth, and that markets on their own cannot deliver prosperity. They argue for 'mission-oriented' investment, and drawing on parallels with the 1930s, push for a policy focus on stimulating reluctant businesses' desire and courage to invest, not just making it 'easier' to invest. They stress that markets can't find a green direction on their own because there is no 'ready-made route'; the variety of green technological innovations, policy directives and incentives are not coherent enough to yield certainty and growth, and therefore to attract finance. "The problem is that there is still a somewhat fundamentalist understanding of the nature of the free market as neutral and unregulated, when in fact markets would be much more dynamic and profitable if the playing field were clearly and intelligently tilted" (Mazzucato 2015a, p. 245).

In the UK context, the Governor of the Bank of England (Carney 2016) suggests that there is a growing (macroeconomic) case for action, but also highlights 'transition risks' in the shift to a low-carbon economy. This includes a lack of information in the finance/investment world about climate-related risk (and opportunity), where companies don't know how to report these risks – or even what to report – and investors, in turn, cannot access information to assess climate-related risks in their portfolios. Furthermore, the uncertainty around scale and timing of (market) adjustments needed highlights the importance of information for a resilient financial system. There has also been an increased interest over the past several years of the need to tackle demand, rather than 'decarbonis[e] an everincreasing energy supply' (Holmes 2010). These observations strengthen the case that new methods and models are needed to tackle the risk and uncertainty around low-carbon investments, if mainstream finance is to be harnessed.

One area which requires long-term thinking (and investment) is infrastructure. Markets alone cannot provide effective infrastructure investments, let alone reorient finance towards sustainable infrastructure markets, and there is therefore a role for public policy and public finances, with government playing a leading role in shaping and directing action, while the private sector will have a significant part in infrastructure investments (Mazzucato & Perez 2015; New Climate Economy 2016). More generally, public policy could be best oriented towards (green) transformation by moving away from focusing on market (and government) failures towards a framework focused on "maximising the transformative impact of policy that can shape and create markets" (Mazzucato 2015a, p. 636). This suggests focusing on the how public policy can affect the direction of change, including shaping and creating markets and socialising risk and rewards. Governments' role could be seen as establishing the frameworks, with the private sector making the investments, with financial policymakers' role helping to develop the frameworks (Carney 2016). Others highlight the importance of alliances between government, business and civil society actors (e.g., Schmitz 2015), and the emerging 'civic energy sectors', i.e., local government and civil society institutions and structures involved in energy services provision, which could be a focus for such partnerships (Hall et al. 2016). We suggest there is a gap in the literature on the role of financial institutions in transforming energy systems. Our work aims to contribute to filling that gap.

This paper is part of ongoing research into the possibility of harnessing mainstream finance in the UK to address energy efficiency and energy demand, as part of a systemic transition towards a low-carbon energy system. The project considers the context of a necessary shift towards sustainable development, and the difficulty in orienting large-scale finance towards lowcarbon development due to uncertainty and lack of supportive institutions and policies. Here we focus on how finance can be reoriented towards improving energy efficiency in the UK domestic sector as a salient example, considering recent initiatives such as the Green Deal and large scale retrofitting. We consider future policies and approaches to accessing finance. These include existing institutions and tools, such as the Green Investment Bank and green bonds, and newer ideas and initiatives such as the European Commission's Efficiency First initiatives, reframing energy efficiency as (green) infrastructure for policy and investment purposes, utilising revolving funds for financing large scale domestic retrofits, and developing a civic energy sector in the UK. The paper turns to previous experience in domestic energy efficiency policy and initiatives, before moving on to consider the role of green finance and a look at how energy efficiency is framed. We then look at some new tools and methods before a discussion of our work so far.

Domestic energy efficiency

In Europe the case for improving energy efficiency in buildings is compelling due to their large share of overall energy demand, and high potential for energy performance improvements – as well as European Commission targets of reducing energy consumption (European commission 2011). In the UK, specifically in the domestic sector, retrofitting is significant in considering energy efficiency and greenhouse gas emissions due to the majority of residential buildings being constructed before 1980 with a slow turnover rate (Sweatman & Managan 2010). An estimated 25 % of UK carbon emissions come from domestic energy usage, predominantly space and water heating, despite overall trends of reducing energy use from 1990 onwards (Palmer & Cooper 2013). Below we describe two large scale interventions in recent years: the Green Deal, a flagship policy of the previous government aimed at large scale refurbishment of UK homes, and generally considered a failure, and the regional Kirklees Warm Zone scheme, largely considered a success.

THE GREEN DEAL

The Green Deal was an ambitious initiative launched in 2013 by the UK Government to encourage able-to-pay households (i.e., households that are financially sound) to invest in energy efficiency improvements. By using a 'pay-as-you-save' finance mechanism (i.e., repaying a loan through energy bills), it aimed to deliver large scale retrofits without public subsidies in an age of austerity (Rosenow & Eyre 2016; Hall & Caldecott 2016). Along with the Energy Company Obligation (ECO), the Green Deal was intended to improve residential energy efficiency, replacing two previous policies for household emissions reduction, the Carbon Emissions Reduction Target (CERT) and the Community Energy Saving Programme (CESP), as well as the fuel poverty reduction programme Warm Front (Rosenow & Eyre 2013; Marchand et al. 2015). It is widely regarded as a failure, with original intentions of refurbishing millions of homes by 2020 failing to materialise, as only around 20,000 home energy improvements were funded 2013-2015 (Hall & Caldecott 2016). Rosenow & Eyre go so far as to say, "In our view, the Green Deal is probably the biggest failure in the history of UK energy efficiency policy" (p. 141), and its introduction "resulted in a collapse of the domestic energy efficiency market" (p. 144).

The failure of the Green Deal to attract householders is attributed to a variety of flaws in its planning and execution. For example, Rosenow & Eyre (2016) identify three areas in which the Green Deal met pitfalls. First, it suffered from poor policy design, with no guarantee of level of energy savings and exclusion of more expensive measures, such as major refurbishments. Second, it had limited financial appeal, with interest rates above mortgage rates or high street secured loans. Drawing on surveys in one local authority, Marchand et al. (2015) also point out high interest rates were a barrier, and in addition highlight that the upfront assessment costs, the Green Deal Advice Reports (GDARs), were priced higher than many households were willing to pay, increasing the upfront cost barrier. And third, there was narrow engagement with consumers, looking solely at financial savings, when effective engagement would consider home aspirations such as comfort, well-being and health. This suggests that households were viewed as rational economic actors whose major barrier to refurbishment was lack of capital, although evidence from research and energy efficiency practitioners did not support this view. Marchand et al. (2015) also point to the lack of awareness among consumers, but argue that saving money was the primary motivation for involvement, not increasing comfort levels, suggesting a financial based engagement might not have been entirely mistaken. So,

while some of the reasons for failure are disputed, there seems to be agreement that the Green Deal did not pay enough attention to successfully engaging with consumers, so as to deliver an attractive package for widespread take-up.

In addition to the above, the Green Deal failed to leverage private investment, resulting in a high cost to the taxpayer, when in fact the political attraction of the Green Deal was private finance without government support (Rosenow & Eyre 2016; Hall & Caldecott 2016). Hall & Caldecott (2016) suggest the Green Deal already established an innovative financing mechanism, but failed to achieve demand to make it work. They offer new policy recommendations addressing the shortcomings of the Green Deal, but still following the principles of fiscal constraints on the government and leveraging private investments. These include creating a new home improvement scheme, which would offer loans at lower interest rates provided by high-street banks, underwritten by the government ('Help to Improve' modelled after the 'Help to Buy' policy, a UK government programme that aims to help first time home buyers). They further recommend allowing households to integrate revenue from decentralised renewable energy schemes into the home improvement loans. For example, if households chose to finance the cost of installing renewables with a home improvement loan, the revenue they would qualify for would be discounted from their payments. This has the advantage of funding feed-in tariffs (FITs) and the renewable heat incentive (RHI), as domestic renewable deployment subsidies are phased out. It is, however, worth considering whether these suggestions do enough to address the failings of the Green Deal, both as a potential policy and with regards to palatability to policymakers.

KIRKLEES WARM ZONE SCHEME

A variety of retrofit schemes have been proposed and some implemented with the goal of improving domestic energy efficiency, thereby tackling fuel poverty and reducing carbon emissions. One of the largest, and arguably most successful, was the Kirklees Warm Zone scheme (KWZ), which retrofitted insulation in 51,000 homes in the Kirklees area in West Yorkshire in 2007–2010 (Webber et al. 2015). Webber et al. report from an extensive research of KWZ with data from (2007) before and after (2011) the scheme.

KWZ was the initiative of the local authority (Kirklees Council) and was managed by a not-for-profit local energy company (Yorkshire Energy Services) (Webber et al. 2015). It offered free assessments and surveys – in contrast to the Green Deal (Marchand et al. 2015) – and where feasible, free loft and cavity wall insulation, installed by the private sector (Webber et al. 2015). Of 176,000 households, 51,000 had measures installed. The high uptake, which was similar in low, middle and higher income areas, was ensured through sustained marketing and household visits; quality of installations and customer engagement were emphasised (*ibid*.).

The results of the Webber et al. study suggest the KWZ scheme was more successful than standard methodologies would suggest; specifically, it was more effective in energy demand reduction in middle and higher income areas than predictions would suggest. They attribute this to lower performance gaps and rebound effects than commonly predicted. The scheme cost £20.9 m, £11.7 m provided by Kirklees

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Council, and the rest by power company Scottish Power (Butterworth et al. 2011). Webber et al. (2015) estimate direct annual savings of £6.2 m, projecting a total 25 year savings of £148–218 million, and a 14.8 % saving in energy use across participating households. Additional significant savings derive from health related benefits, local economic stimulation and a rise in house price value (Butterworth et al. 2011; Webber et al. 2015).

The lessons learned from this scheme match the conclusions (Frontier Economics 2015) that a coordinated, areabased approach could help realise potential of energy efficiency programmes, through supporting local markets and overcoming behavioural barriers. Frontier Economics highlight how direct funding from government for domestic energy efficiency as infrastructure adds value, for example through use of local (authority) knowledge on fuel poor and vulnerable households which would benefit most by direct delivery of an infrastructure programme. Attempts to replicate the success of KWZ in other schemes should consider that it was cost effective, but that it cost money, requiring an investment of public finances, which might be more difficult to access with austerity measures and the end of the CERT and CESP policies.

Green finance

As noted in the previous section, financing large scale domestic energy efficiency is a policy conundrum, especially in an era of spending cuts and austerity policies. Cost-effective opportunities to improve household energy efficiency are not being taken, with large-scale investment opportunities limited (Holmes 2010). Before the Green Deal, Holmes describes the barriers as poor opportunities to purchase retrofit packages and limited access to capital for households; insufficient capital to invest in demand reduction for energy service providers; and a perceived limited consumer demand for energy efficiency products and services among investors, reflecting the fragmented market. While the KWZ scheme successfully addressed several of these barriers, it has not been repeated, partly due to policy preference for market-based solutions and limited public investment as subsidies, as seen in the Green Deal.

The search for a way forward includes recent work on *green finance*, which can be seen as allocating investment towards sustainable technologies and energy efficient products and services, along with developing appropriate institutions and policies. There are calls for international action to make green finance more than a niche in the medium term, with green investment seen as "a major opportunity for both long-term investors and macroeconomic policymakers seeking to jump-start growth" (Carney 2016, p. 13).

In the UK context, the turmoil in the finance world and the continuing lack of confidence in the banks on the one hand, and the lack of a coherent strategy for delivering decarbonisation of the economy on the other, has resulted in a short-term lack of private capital available for investment (Holmes & Mabey 2009). A green finance strategy could "combine targeted interventions in the short term stimulus period with new policies and mechanisms to support rapid medium term expansion", but it would have to "provide a credible and transparent

investment narrative for private actors" (p. 3). They suggested a green stimulus package could aid the UK's recovery from the recession, but stress that the complexity of the transition would require changing demands and necessitate government (financial) support beyond the short term (sic) needs of the economic crisis. However, Mazzucato and Perez (2015) argue that policies shouldn't be based on the 'false assumption of the existence of a shortage of finance', rather the quality, not quantity, of finance is important. Either way, public finance has an important role to play, at least as a catalyser to attract private finance (New Climate Economy 2016).

Two proposed tools for stimulating investment and signalling policy directions are a green investment bank and green bonds, both of which are already playing a part in UK green finance.

GREEN INVESTMENT BANK

Following the global recession of 2008, there were suggestions in the UK that a 'Green Infrastructure Bank' could catalyse private sector investment through careful use of public finance, in order to secure private investment in low carbon infrastructure (Holmes & Mabey 2009). Specifically in the context of domestic refurbishment for energy efficiency, Holmes (2010) considers a Green Infrastructure Bank as a vehicle that could provide upfront capital for householders and an aggregation of investment opportunity for investors.

The plans for the UK's Green Investment Bank (GIB) were announced in March 2011 by then Chancellor George Osborne, amid controversy with and beyond the government over its role and powers (Harvey 2011). It was launched in 2012 with the UK government as its sole shareholder, and its investments are used to fund green infrastructure in the UK, taking on 'more difficult' infrastructure projects and helping lower the cost of capital for green projects (GIB 2017). In a speech in June 2015 then Business Secretary Sajid Javid announced the intentions to privatise the GIB (Javid 2015), partly in order to attract new investors and private sector funds. Despite assurances that the 'green purpose' of the bank was being safeguarded (GIB 2017), concerns have been raised that its fundamental role of providing 'patient capital' (see Mazzucato 2015b) would be lost; this concern is all the more salient as a government green paper (HMG 2017) suggests that a lack of patient capital might be reducing the UK's successful conversion of start-ups to successful businesses. At time of writing, the preferred bidder chosen by the government is Australian investment bank Macquarie, leading to fears of the GIB being stripped of its assets and losing its environmental purpose (Vaughn 2017).

The GIB has so far lent almost exclusively to utility scale projects, including private power provision or large scale public sector projects (Hall et al. 2016), in contrast, for example, to the German public development bank KfW, which uses promotional energy lending to fund many smaller scale loans (Hall et al. 2016; KfW Bankengruppe 2012). Its contribution to the demand side appears to be through energy efficiency measures to large scale consumers, such as National Health Service (NHS) energy efficiency programmes, council street lighting upgrades, and commercial or public retrofits (GIB 2017). It has so far not played a major role in domestic energy efficiency initiatives.

GREEN BONDS

One of the new green finance tools suggested for sustainability related investments are green bonds (e.g., New Climate Economy 2016). These are bonds with proceeds that are "ring-fenced to fund eligible climate change mitigation projects, with a focus on renewables, energy efficiency and transport" (Blackrock 2016, p. 13). They are considered an example of a stable, long-term investment as part of green finance (Carney 2016), a growing investment opportunity, and a tool for fixed income investors to support climate change mitigation (Blackrock 2016). Internationally, there are calls for governments and investors to set common standards for green bonds and scale them up in order to unlock capital for investment and enhance liquidity needed for sustainable infrastructure (e.g., New Climate Economy 2016). Holmes & Mabey (2009) also consider green bonds as a way to raise finance for low carbon infrastructure, with "new products for both institutional and retail investors", and as a way of engaging both the public and the investment community in decarbonising the UK economy. Green bonds raised from private investors and issued by the Green Investment Bank have been suggested for domestic energy efficiency programmes (Holmes 2010).

In the context of (green) infrastructure, "[t]here is a strong consensus in the investment community around the theoretical merits of raising green bonds and that the Government should step in with public funds to rescue failing project finance deals." (Holmes & Mabey 2009, p. 4). They argue that post-economic downturn, green bonds could help long-term recovery, in creation of jobs for the future – rather than part of a cyclical fiscal programme. This could instil confidence in policy direction. Further, they argue that government-backed instruments like green bonds could help address the investment gap in green infrastructure, by capturing investors' attention both in the UK and worldwide. This would help raise funds from the private sector and consumers, rather than taxation.

Green bonds are a small but fast growing part of the fixed income market. They could be issued by governments, but also by "banks, property companies, car makers, food producers, conglomerates and cleantech companies" (Blackrock 2016, p. 13). Among the first governments to act, France launched its first green bond in January 2017, which - unlike other governmentissued bonds - is committed to identifying and monitoring expenditures supporting an energy and ecological transition (Robert 2017). Indeed, these are not normal investments, and Holmes & Mabey (2009) compare green bonds to war bonds, as 'cause-motivated capital'. This might be an example of 'mission-related' (public) investments (Mazzucato & Perez 2015), used to drive innovation and investments in a desired direction. While the potential is there, so far green bonds, like the Green Investment Bank, have failed to play an important role in domestic energy efficiency.

Framing energy efficiency

Financing large-scale (domestic) energy efficiency suffers various setbacks. In this section, we consider how a change of perspective might help attract investment. Evidence shows that building energy efficiency improvements are not always taken up, even when they are cost-effective measures, both in the domestic sector (Holmes 2010) and more broadly (IEA 2012). Webber et al. (2015) review the many non-technical barriers to uptake, including lack of awareness and a variety of households' concerns around upfront cost and access to finance, but also around risk, disruption, and a lack of trust in information sources, suppliers and technologies. While this is partly a demand-side issue, reframing energy efficiency as a viable investment might not only provide more finance opportunities and help address the investment gap, but could shift help the discourse on energy investment, which is currently largely supply side-oriented, and start to address households' concerns. Reframing energy efficiency as an infrastructure investment, and comparing supply and demand side investments, is one possibility.

ENERGY EFFICIENCY AS INFRASTRUCTURE

One option to harness the financial sector towards the demand side of energy systems is considering aggregated energy demand measures as infrastructure. For example, there is a strong case to see home energy efficiency not only as an infrastructure issue, but as one with investment priority (UKGBC 2014; Frontier Economics 2015; Amon & Holmes 2016). Frontier Economics suggest domestic energy efficiency investments (such as insulation and draught proofing and efficient boilers) fit the broad definition of infrastructure characteristics as capital investments in physical structures, as well as the broad definition of infrastructure functions of input to the production of goods and services, by freeing up capacity in the energy system. The fact that this is done via demand rather than supply does not change the economic (or energy savings) outcome. They conclude that if energy efficiency is seen as infrastructure, then government intervention is required both in order to maximise the social good of investments, and in order to overcome barriers to uptake.

The role of government would be both to supply an overarching strategy and to provide capital spending where an investment gap now exists; this would help instil confidence in the markets, overcome barriers to delivery, and address market failures of previous programmes (UKGBC 2014; Frontier Economics 2015; Amon & Holmes 2016). It also has strong support from business and local authorities (Frontier Economics 2015). The infrastructure approach could help poorer households, create jobs and stimulate the economy all around the UK, in addition to energy benefits of security and emissions reduction (UKGBC 2014). There is also a finance-related logic: Frontier Economics (2015) suggest an energy efficiency programme would make a sound investment with comparable benefits to other major infrastructure investments, estimating it would bring £8.7 bn benefits to the UK (plus indirect benefits such as health improvements), whereas approved and considered large transport projects (London's Crossrail, phase 1 of high-speed rail connection HS2, and new roads) have estimated benefits in the range of £7.2 bn-£9.9 bn. An energy efficiency programme under the right policies could therefore attract investors who currently invest in infrastructure projects. Moreover, treating energy efficiency projects as infrastructure means they would be subjected to economic appraisals - these would highlight their benefits, not only their costs, and could help raise their profile, ultimately contributing to economic growth (Amon & Holmes 2016).

From a policy perspective, State Aid regulations from the European Commission constrains aid energy efficiency meas-

ures to 30-50 % - the lowest of all environmental aid measures, while energy infrastructure is allowed aid of a full 100 % of eligible costs (Amon & Holmes 2016). There is also a lack of guidance on how energy efficiency measures could enter competitive bidding processes to be eligible for high State Aid. Clarifying the rules and defining energy efficiency as infrastructure could therefore unleash both the potential of public-private partnerships and the power of local and regional authorities to deliver energy efficiency and demand reduction measures. Finally, Amon & Holmes (2016) suggest shifting energy efficiency to the capital expenditure budget in order to signify it is not a short-term measure, and should compete with infrastructure expenses such as rail, road, and power supply rather than health or education needs. The multiple benefits of energy efficiency would make it competitive on these terms. In sum, this reframing could help finance and deliver energy efficiency with multiple benefits to the energy system as a whole.

LINKING SUPPLY AND DEMAND

A further consequence of the infrastructure approach is linking energy demand and supply, as "[t]reating energy efficiency as infrastructure and integrating it into wider national infrastructure planning means supply side investment needs will fall as projected demand falls, thus reducing the risk of asset stranding and reducing costs to society" (Amon & Holmes 2016, p. 2). This approach could be extended to energy security. For example, considering gas security, E3G (Gaventa et al. 2016) suggest demand-side investments should be treated as energy security infrastructure and given parity with other forms. In other words, investments in new gas infrastructure should be tested against other alternatives including electrification, but also demand reduction and demand response: "demand reduction should be seen as a policy option and infrastructure investment that can be actively deployed to address energy security problems" (p. 28).

This could be achieved by least cost investment requirements assessing both supply and demand side possibilities (Gaventa et al. 2016). RAP (Cowart 2014) gives examples of least cost requirements succeeding in the US, where many states require supply-side investments to be tested against demand-side options before permits (e.g., for power plants or transmission lines) could be issued. California's Loading Order policy requires investments in energy resources to be directed first at efficiency and demand response. This has succeeded and "California utilities and government agencies now invest well over \$1.5 billion per year in end-use efficiency, leveraging much greater investments from businesses and households" (Cowart 2014, p. 2). This and other experience in North America shows that aggregation work with customers, delivering energy efficiency and demand response in large quantities, can lower cost to customers for the same level of reliability. There is a case for allowing demand side measures to compete against supply side measure both in the short-term energy markets, e.g. electricity supply, and in the longer-term capacity markets, e.g., bidding to supply electricity in terms of megawatts of reduced power from efficiency or demand response, rather than in megawatts of produced power (Cowart 2014). In addition to enabling another route of investment in energy efficiency, this linking of supply and demand can help achieve least cost or efficiency first goals for energy capacity and security.

New tools and models

We turn next to several current initiatives. These are new or existing models which have more recently been suggested as appropriate tools for energy efficiency finance, and could potentially be combined with, or benefit from, ideas discussed above around reframing energy efficiency and green finance policies and institutions. These include the European Commission Energy First initiative, the revolving fund model for financing domestic energy efficiency, and the proposed civic energy sector institutions.

EFFICIENCY FIRST

'Efficiency First' is the principle of considering the potential value of investing in energy efficiency in decisions about energy system development. It was formally endorsed by the European Commission in 2015. In practice, it means, "giving energy efficiency a fair chance in the models and impact assessments that policy-makers use to make decisions, strengthening those laws that already target efficiency, and integrating it into all other Energy Union policies" (European Climate Foundation 2016a, p. 2). Energy efficiency in this context is defined as demand management, including both energy savings, i.e., reducing the amount of energy used in delivering energy services, and demand response, i.e., shifting consumption patterns – but not necessarily volume (European Climate Foundation 2016a).

The ECF suggests various tools and methods for financing energy efficiency investments (European Climate Foundation 2016b). These include: prioritising energy efficiency in lending and other criteria of redistributive policies; redefining national efficiency funds as "economically sound entities pursuing a goal of economic viability and cost recovery rather than profit making" (European Climate Foundation 2016b, p. 5); classification of energy efficiency as 'productive debt' (i.e., the benefits of the activity being financed are greater than the cost of the debt); and revising the EU Emissions Trading System (ETS) revenue recycling rules to ensure spending on end-use efficiency. Amon & Holmes (2016) are critical of the Commission, suggesting the EU has to walk the walk of Energy Efficiency First, not just talk the talk, for example by linking energy efficiency more explicitly to energy infrastructure planning.

A German Green Paper (BMWi 2016) considers Efficiency First in a "National Action Plan on Energy Efficiency". The aim is "reducing energy consumption by raising energy efficiency" (p. 4), specifically reducing demand by investing in efficiency technologies, with remaining emissions cuts coming from renewables. Behaviour change is discussed primarily in the context of rebound effects. Their modelling exercises suggest that the efficiency policies will increase investments in Germany, a large part of which would be in the construction sector. However, funding is largely expected to come from traditional instruments, including direct subsidies and low-interest loans, which might limit the appeal of this model to UK policymakers. The paper sets out ways to further develop market solutions for energy efficiency services, focusing again on traditional solutions: technological innovations assessed by market players, market transparency and standardisation. In the UK context at least, our review suggests alternative ways to develop markets and engage consumers are needed in addition to this efficiency focus, two of which we present here.

REVOLVING FUNDS

The basic principal of a revolving fund is that capital raised can be made available more than once, as money circulates between the users and the fund. Repayment of loans with interest replenishes the fund to make further loans. Revolving funds are established with the intention of being self-sufficient for long periods, with initial capital coming from public sector or private sector loans (Akvopedia 2015).

Considering revolving funds for domestic energy efficiency programmes, Gouldson et al. (2015) start from the assumptions that the social case for fighting climate change doesn't translate into a case for private investment, as businesses and investors have short-term financial return criteria; and that in an age of austerity public funds are limited. Therefore, finding ways of mobilising private and public sector finance is critical. They therefore suggest a revolving fund model for household energy efficiency programmes, where initial funding - probably from private investors - is lent to a 'special purpose vehicle' (SPV), which in turn in invests funds in energy efficiency measures. Households are encouraged to participate by being offered a share of the savings generated as costs are being repaid (and all savings once investment costs are repaid in full). The regular payments from households to the SPV allow it to pay installers, whilst repaying investors over a long period. The aggregation from individual households to large numbers offers both a scale of investment attractive to finance, and economies of scale to reduce costs. The basic structure of the proposed revolving fund is shown in Figure 1.

Their modelling exercise suggests that full realistic potential of home energy improvements would require an overall investment of £33.7 billion, at £1.5 billion a month; the 'recycled' funds could save an estimated £8.9 billion – more than 25 % – over several decades. The scheme is estimated to result in a 6.7 % drop in domestic emissions – actually a fairly small saving. Importantly, they claim this type of revolving fund model shows a large scale domestic retrofit scheme (or other public interest programmes) could essentially be made cost neutral over time.

The model also raises important questions (Gouldson et al. 2015). For example, it requires the government to underwrite loans to households, in order to mitigate the risk to investors; on the one hand, this could be seen as a reasonable incentive, a

low-risk low-return investment; on the other, it could be seen as a subsidy to the private sector through reducing risk. Also, it limits action to economically attractive measures, which might not be enough to meet climate change commitments. Finally, local government and community groups could lose autonomy in deciding local priorities and concerns.

CIVIC ENERGY SECTOR

Hall et al. (2016) focus on the role of a 'Civic Energy Sector' in financing a low carbon energy transition. The civic energy sector involves local government and civil society structures involved in energy services provision. These are energy systems owned by citizens, communities, co-operatives and local authorities. In contrasting the UK and Germany, Hall et al. show that the UK frames the transition to a low carbon energy system in terms of state creation of competitive markets, due to its more neoliberal political economy which saw privatisation of a national, centralised electricity system, compared to Germany's federalist politics and infrastructure and its co-ordinated market economy.

In Germany, the civic energy sector is more developed than in the UK. This is partly due to the more developed local banking system, for example, savings banks and the cooperative banking group provide both capital and developmental support to civic energy, including civil ownership of energy assets (Hall et al. 2016). The public development bank KfW is a key player: it has a strong credit rating which it uses to source capital and offer refinancing options for energy efficiency loans and renewable energy projects, enabling the local energy sector to grow.

In the UK, energy project finance comes largely from banks and the balance sheets of the utility companies themselves, both relying on centralised, international sources of capital (Hall et al. 2016). This can increase exposure to volatility, and also limits availability to fund small or medium scale projects. This makes it difficult for civil society energy schemes to source investments, meaning there is a 'finance gap' for projects below city level (*ibid*.). While the Green Investment Bank could have at least partially addressed this, it predominantly invests in larger private sector or public projects. Thus, while in the UK the market based finance is structurally unsuited for supporting small scale energy projects, German state policies have allowed a network of smaller scale financial arrangements.



Figure 1. Basic structure of a revolving fund for financing household energy efficiency measures, adapted from Gouldson et al. (2015).

Despite the remaining finance gap, the UK has a small but growing civic energy sector, with a potential to play an important role in financing and supporting energy efficiency and demand side management activities. The recent government Industrial Strategy Green Paper (HMG 2017) suggests stronger, better developed sectoral and local institutions are good for economic competition. The description includes local financial institutions and local enterprise partnerships, compatible with the idea of a strong civic energy sector, although the emphasis is on the private sector, for example, giving businesses "direct role in shaping the future of their local communities" (HMG 2017, p. 120).

Discussion

There is currently a global appetite for investment in energy efficiency measures as part of sustainable development. Massive investment is required if energy efficiency is to make a real difference to reducing energy demand and mitigating greenhouse gas emissions. One of the challenges is harnessing large scale finance for these measures, especially in the wake of the global recession where many countries, including the UK, are cutting spending and implementing austerity measures. Using the example of the UK residential sector, we consider what policies, institutions and models might encourage mainstream investment in the demand side of the energy system. This example is especially poignant following the closure of the UK's main support mechanism, the Green Deal, without a clear successor policy in place.

The role of government is central to this discussion. This includes policies and leadership, as well as public spending. While most of the papers reviewed here do not question the austerity paradigm, Mazzucato & Perez (2015) state that weaker Eurozone countries have had too little spending in areas that create new markets and opportunities, including R&D. Further, their analysis shows that across Europe, privatisations in the 1990s have caused a fall in private R&D, undermining the claims that Europe's financial problems result from too much debt; in fact, a better diagnosis is too little mission-oriented strategic spending. This puts into question the emphasis in some models on subsidy-free policies, and highlights the need for leadership. Transforming to a greener economy, including energy efficiency, can be seen as an innovation challenge; Mazzucato (2015a) suggests focusing on how public policy can affect the direction of change, including shaping and creating markets and socialising both risk and rewards. UK government policy, however, highlights the role of markets and suggests that while there is a clear role for government, "[i]t is the private sector that will ultimately be the driving force behind our low carbon economy" (HMG 2017, p. 89).

Various analyses suggest subsidies, zero or low interest loans, and government underwriting of loans could play a key part in mitigating the risk for investment in energy efficiency (e.g., Holmes 2010; Gouldson et al. 2015). The failure of the Green Deal supports this analysis, as lack of low interest loans and subsidies were implicated (Rosenow & Eyre 2016). By contrast, the high uptake of the Kirklees Warm Zone retrofit scheme is partly due to public funds which allowed free assessments and insulation measures (Webber et al. 2015). Underwriting loans to households could be seen as a win-win policy, for example, if most of the returns of a revolving fund were reinvested into the fund itself; but it can also be seen as an effective subsidy to the private sector (Gouldson et al. 2015), through socialising risks, but not rewards, in Mazzuacto's terms.

A variety of models and institutions for attracting investment and enabling large scale energy efficiency initiatives are available. The use of traditional instruments for financing energy efficiency in the Efficiency First initiative, including direct subsidies and low-interest loans, appeal to German policymakers, but might make it more difficult to sell to UK policymakers. The Green Investment Bank and green bonds are already playing a role in green finance. They have shown some success in attracting private finance, but have so far had limited effect on smaller scale demand side measures, such as domestic retrofits for energy efficiency. The potential privatisation of the GIB might make it more difficult for it to fund less proven, non-traditional investments. One of the possibilities to increase the appeal of the residential energy efficiency markets is aggregation of many small projects, potentially viewed as infrastructure. The infrastructure approach is a powerful one, as it shows how large scale investment could make a real difference in energy efficiency, while lowering the cost per household through economies of scale. If this were combined with initiatives which take advantage of local knowledge, like Kirklees Warm Zone, this could potentially offer an attractive package.

A well-developed civic energy sector (Hall et al. 2016) could help develop vehicles for future schemes. However, the public subsidy nature of Kirklees Warm Zone is less appealing in the current economic and policy climate, and perhaps is also difficult to duplicate due to the centralised nature of power and finance in the UK. Various tools which could reduce the cost to the public purse have been suggested, including revolving fund models and funding sub-city scale projects from the Green Investment Bank. In addition, large, centralised schemes could lead to local government and community groups losing autonomy in deciding local priorities and concerns (Gouldson et al. 2015). Still, the various cases and models reviewed here suggest that large scale energy efficiency improvements which are completely free of public subsidy might be an unrealistic goal. In addition, this focus limits action to economically attractive measures, which might not be enough to meet climate change commitments (Gouldson et al. 2015).

Finally, the role of households and behaviour also need to be considered. The failure of the Green Deal to engage with consumers, compared to the door-to-door approach of Kirklees Warm Zone, which made use of local trusted actors, highlights the need for engagement and the advantage of local schemes. Further, while there is evidence that the pay-asyou-save model is attractive to many households, the question of those not able to pay - who are often fuel poor and might benefit most from home retrofits - needs addressing as well. Holmes (2010) suggests sliding scales of subsidy according to household ability to pay, although this might add layers of bureaucracy which Kirklees Warm Zone avoided. Webber et al. (2015) highlight how many discussions of retrofit schemes focus on technical, financial and economic barriers to uptake of energy efficiency measures, but do not address deeply embedded behaviours and practices which determine energy use in homes (and other buildings), and ignore impacts of participation on behaviours and practices, beyond relying on new technologies to change behaviour. To put it more broadly, there is little attempt in most of the work reviewed here to rethink energy (services) demand as such, rather a reliance on energy efficiency, i.e., new technologies and physical buildings. If we are serious about energy demand reduction, this too should be considered.

ONGOING RESEARCH

In our ongoing research, we aim to continue our analysis of these different models and approaches and examine what further measures may be needed to overcome structural and behavioural constraints to large-scale investment in energy efficiency and demand management measures. Our central research question in this context is therefore: How can investment flows be reoriented towards widespread domestic energy efficiency improvement and energy demand reduction? We will consider the potential mismatch between policy framings around costs and benefits of interventions to households, where people are often portrayed as rational economic actors; and financial (community) framings of risks and rewards, where there is more recognition that people are not rational actors. If the investment community is not convinced of the viability of the policies, they will not invest in them; following the failure of the Green Deal, new proposed policies might not be an easy sell. We therefore see the central twin challenges as policies which can scale up domestic energy efficiency initiatives, successfully engaging households to participate, and finding business models which can attract finance to such projects.

Our work so far suggests several interesting avenues of research that could help to address the above research question. These include considering what challenges and risks are associated with energy efficiency investments; what market, policy and other barriers are driving and obstructing such investment; what innovative business models could make such investments more viable; what policies can best support and encourage these new models; and how can policy make public spending most effective in reorienting investment. We will draw on interviews with members of the investment community and policymakers to ground our research in current thinking and attitudes, to assess the relative merits and attractiveness of the various approaches we have begun to outline here.

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