NON-TECHNICAL BARRIERS FOR CHALLENGING LOCK-IN TO URBAN ENERGY SYSTEMS: LEARNING FROM INTERNATIONAL CASE STUDIES

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In order to meet its 2050 target of 80% carbon reduction, and hence evolve towards a more sustainable energy future, the UK faces a significant challenge of restructuring its energy system, by demonstrating more decentralised energy systems based not only on technological but also on more innovative governance, financial and social approaches. Four exemplar international cases have been compared and critiqued in order to demonstrate the variety and inter-relationship of the non-technical barriers involved during their implementation. This study finds that the main non-technical barriers are not necessarily financial, as is often believed. Governance barriers also play an important role in the success or failure of a project. Social barriers such as public apathy and misinformation regarding energy consumption also often affect the operation of a project. The impacts of the non-technical barriers on the outcome of the four cases are also evaluated and recommendations are provided on overcoming these barriers with regards replicating similar projects in the UK context. This work also provides potentially valuable implications and learning for the innovative development and initiation of renewable energy systems in a variety of countries and settings.

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Non-technical barriers for challenging lock-in to urban energy systems: learning from international case studies

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ABSTRACT: In order to meet its 2050 target of 80% carbon reduction, and hence evolve towards a more sustainable energy future, the UK faces a significant challenge of restructuring its energy system, by demonstrating more decentralised energy systems based not only on technological but also on more innovative governance, financial and social approaches. Four exemplar international cases have been compared and critiqued in order to demonstrate the variety and inter-relationship of the non-technical barriers involved during their implementation. This study finds that the main non-technical barriers are not necessarily financial, as is often believed. Governance barriers also play an important role in the success or failure of a project. Social barriers such as public apathy and misinformation regarding energy consumption also often affect the operation of a project. The impacts of the non-technical barriers on the outcome of the four cases are also evaluated and recommendations are provided on overcoming these barriers with regards replicating similar projects in the UK context. This work also provides potentially valuable implications and learning for the innovative development and initiation of renewable energy systems in a variety of countries and settings.

1 INTRODUCTION

In 2008, the UK Parliament passed the Climate Change Act, which set a legally binding target of reducing the UK greenhouse gas (GHG) emissions by 80% compared to 1990 level by 2050 (DECC 2008). In order to reach this target, a shift has to be made towards more sustainable and renewable forms of energy, and the significant challenge of restructuring the energy system has to be addressed. The main drivers for this transition are the necessity to reduce GHG emissions as well as to increase the share of renewables in the energy mix and to make the use of energy more efficient, as well as rising electricity demand and the price of fuel, liberalisation of the markets and concern over energy security (GOS 2008; Rydin et al 2012).

Indeed, a number of towns, cities and communities in the UK and worldwide have already pioneered unique and effective approaches to more decentralised energy (DE) systems leading to enhanced GHG emissions reductions. The implementation of these approaches, however, is (in the main) a long and complicated process that requires not only financial investments but also support from the authorities, community engagement and other factors that if underestimated can negatively affect the outcome of the project.

The current UK electricity system is highly centralised and relies heavily on fossil fuels. Although this centralised model is historically proven, it has significant disadvantages (Allen et al 2008) whereas DE systems frequently claim to be more resilient, reliable, efficient and environmental friendly, as well as more affordable and accessible whilst offering greater levels of energy security (e.g. Coaffe 2008). DE generation and supply is, however, yet to play a significant role in the UK's energy systems. The development of DE systems in the UK is much slower when compared to similar developed countries such as Denmark, Germany, Sweden and others (Bergman and Eyre 2011).

1.2 Non-technical barriers: types and definitions

It is often stated (Blumstein et al 1980; Painuly 2001) that energy initiatives face barriers during their implementation, and sometimes in operation. The diversity of the potential barriers is notable and varies from structural to behavioural (Shove 1998).

In the context of DE initiatives, according to Verbruggen et al (2010: 852), 'barriers' are 'man-made factors or attributes of factors that operate in between actual and potential renewable energy development or use. They can be both intentional and unintentional. A barrier prevents or hinders action, impedes progress or achievement in realising potentials'. IPCC (2007: 810) defines a barrier as 'any obstacle to reaching a goal, adaptation or mitigation potential that can be overcome or attenuated by a policy, programme, or measure'. These definitions characterise barriers as man-made and changeable. Interestingly, however, the definition given by IPCC is focused on financial and regulatory aspects, and does not take into account social aspects, which, as will be discussed, can also play an important role.

Painuly (2001) states that non-technical barriers can also be technology specific, or specific to a country or a region, and can be analysed at several levels, from broad (e.g. financial) to more detailed or specific (e.g. high interest rate). Whilst Painuly (2001) mainly focuses on the lack of regulations, it was identified within this research that existing regulations can also create a barrier.

1.3 International case studies

The four case studies summarised in Table 1 were chosen due to their geographic diversity and their variety of financial and technical approaches, together with their potential, yet unrealised, applicability within the UK context.

Table 1: Case study summary (Chmutina and Goodier 2012)

	Seawater district heating	Morris Model	Energy Saving Partnership	Kungsbrohuset office building
Location	The Hague, Netherlands	Morris County , USA	Berlin, Germany	Stockholm, Sweden
Technology	Seawater heating	PV	Building retrofit	Eco-smart building
Date started	1999	2009	1997	2010
Scale	750 houses	19 buildings; 3.2 MW	1,400 buildings	1 building, 27,000m2
Investment	€10 m	$30 m (in bonds)	NA	€120 m
Instigating party	Vestia (housing corporation)	Morris County Improvement Authority (MCIA)	Berlin Energy Agency (BEA)	Jernhusen
Energy / CO2 reduction	50% of CO_2 reduction	51,500 MWh over 15 years	60,400 tonnes of CO_2/year	50% of energy consumption reduction

2 METHODOLOGY

The case studies presented here represent only a small proportion of all the decentralised urban energy projects currently employed. These four case studies were chosen from an initial list 35, in order to present a range of energy resources, technologies, end uses and types of project intervention; the main criteria being: project innovation; a range of different scales; applicability in the UK context and uniqueness of the project; and financial affordability for investigation and case study development.

In order to identify the non-technical barriers, an extensive web research was initially conducted to identify basic project information and stakeholder contact details. Site visits were then arranged where possible, in order to obtain valuable critical insights and information. 15 semi-structured on-site interviews with the main stakeholders such as project instigators, project managers, local authorities etc. were also conducted regarding barriers and their solutions. Each interview lasted approximately 60 minutes and covered the same themes. The interviews were recorded, transcribed, coded and analysed using Nvivo 7.

3 CASE STUDIES DESCRIPTION

3.1 Seawater district heating system, The Hague

The City of The Hague and Vestia Housing Corporation partnered with Deerns Engineering Consultancy to incorporate seawater district heating in the reconstruction of 750 highly energy efficient houses in Duindorp along the North Sea Coast of The Hague. The technologies involved were not new: the innovation lied in their combination that allows constructing a very efficient system for making sea water the source of energy for heating and cooling homes as well as for heating water all year round (Goodier et al 2012). The overall efficiency of the heat generation process with this system is more than 50% greater than conventional high-efficiency boilers, while the cost to the residents is the same (The City of The Hague 2009). The system is part of the city's plan to use more sustainable energy and is contributing towards making the area 'climate neutral' (The City of The Hague 2009).

3.2 Morris Model: a new way of financing PV for municipal buildings

The Morris Model in New Jersey, USA is a unique method of financing municipal renewable energy projects for public facilities through low-interest bonds, traditional Power Purchase Agreements and federal tax. Traditionally, local governments had two ways of financing solar programmes: either with tax exempt bonds (local government-owned approach), or by entering into turnkey relationships with private solar developers. The project uses a turnkey approach with financing being provided at the lower cost of capital obtained by government. This allows a cheaper financing for the solar development as well as preserving the utilities capacity to borrow from the private capital lending sources for other projects. The model has been replicated in Somerset and Union counties in New Jersey with several other counties in various stages of programmatic review (Pearlman and Scerbo 2010).

3.3 Berlin Energy Saving Partnership (BESP): commercial buildings retrofit

The BESP was first introduced by the State of Berlin in 1995, based upon transferring energy management of state-owned properties to a partner, who uses private capital to self-finance the modernization of building infrastructure necessary to cut energy use and CO_2 emissions, such as refurbishment of heating and lighting, energy management, and 'user motivation'. In return, the partner guarantees annual energy cost savings for the state (Chmutina et al 2012). This model is widely replicated in Europe, as well as in China, Chile and other countries. The next step is the "Energy Saving Partnership Plus", with an aim to extend the focus of the partnership to insulation and window replacement with higher payback periods.

3.4 Kungsbrohuset Office Building: eco-smart office

Kungsbrohuset is a 27,000 m2 property next to Stockholm Central Station. The owner of the building – Jernhusen - wanted to prove that it is possible to build a sustainable office building using readily available materials and mature technologies rather than sophisticated but risky innovations, and to create a development where the environment and energy-efficiency were central considerations. The office space is let to companies that want to increase their environmental credentials (Jernhusen 2012).

4 THE ROLE OF NON-TECHNICAL BARRIERS

4.1 Governance barriers

There are many interpretations of governance (e.g. Blumstein 1980), but it is agreed that governance consists of both structure and process, and involves public, public-private and private activities.

Regulation was a barrier acknowledged across all four cases. According to Blumstein et al (1980), this is the evidence of conflicting goals set by various parties that are directly and indirectly involved in the project; for example: "It's [seawater plant site] part of the coastal defence system against flooding so you can't move any sand around between October and April. It's a tourist place which means that you are not allowed to work there during summer. From May to October you cannot" (The Hague). Here, environmental legislation slowed down the process of construction. Planning permissions were an obstacle that dramatically affected the timing of the project, a common occurrence in any project.

The stakeholders admitted that the projects would benefit from the involvement of not only the local but also the national government: "The only thing we probably would change is to see if the State could do more because they should be doing everything possible to make sure something like this is put into place" (Morris Model). Involvement of the national government can reduce the negative impact bureaucracy has on projects; although dealt with, it required additional time and effort from the stakeholders: "We had to go through all the red tape because the State wants you to do this, but yet it puts up all these barriers so you can't do it" (Morris Model).

Coordination of parties involved was a barrier that created unexpected difficulties: "The main challenge is organisational. To get everybody to co-work with these goals of getting it as energy efficient as we wanted, to work with the environmental situation. Some people just said 'Why are we going to do this? Can't we do it like we've always done it?' That was one of the hardest parts – to keep the line, to keep the focus on the target" (Kungsbrohuset stakeholder). In The Hague case study, a key stakeholder dropped out at the last stage, illustrating that the unexpected change of behaviour or involvement of a key partner can lead to project failures if not addressed on time: "Eneco didn't believe it [the system's efficiency] and they caused us quite some trouble. They retreated, so then we had this gap, which was very bad" (The Hague).

The implementation of the projects required highly qualified specialists passionate about sustainability and demanded resources that were not always available: "There are a lot of regions in Germany where you can do that [BESP], and if we had been more active in this field we would maybe have the possibility to not do 3 tenders a year by maybe 5 or 10, but then of course with more staff. We try, but it's just my colleague and me and that's why it's also a question of capacity to work" (BESP).

4.2 Financial barriers

The common financial barrier in these four cases was financial constraint. Lack of finance was also named as a barrier that does not allow achieving better economies of scale or taking projects on a new level. The BEA is still considering BESP Plus in order to take energy efficiency measures further: "We have the contract for this and we want to do this with some pilot projects, but […] we still have to find the financing ….. The ESCOs cannot finance this" (BESP).

The situation was different with The Hague seawater project, where the lack of funding was more related to governance. The drop-out of the stakeholder created a 25% gap in the project budget, which was eventually covered by the project owner (Vestia) together with the support of a 0.5 mln Euro from the City of The Hague. Vestia agreed to carry the high financial risks in case of project failure; in addition, the scale of the project was reduced from 1,000 houses to 750 houses, which led to a longer than expected payback period. Financial profitability was not, however, the main aim of this project: the chief idea was to prove that it is possible to make heating for the Duindorp area sustainable using a locally available source - sea water.

4.3 Social barriers

Social barriers are obstacles created not only by the end-users, but also by those 'affected' by these projects, such as adjacent communities and those engaged in public consultations. The main problem was a lack of understanding of how the technology worked. This barrier can affect the performance and in some cases led to rises in energy consumption when not supervised by the specialists: "People with low income and low education don't understand exactly how to use all this kind of stuff and they don't care about it" (The Hague). "If the building owner is getting back all the saving measures but he doesn't know about energy management much, of course the energy consumption then starts to rise up again" (BESP). Lack of understanding can also lead to other problems such as lack of interest. It also triggers financial worries: "They [community] immediately associated the cost of the solar project with a potential budget increase even though we kept telling them it wasn't the case. So it required me to do more of a line-by-line budget description for the community so that they trusted and believed that this was not embedded in our budget" (Morris model).

Habits play a crucial role in creating social barriers. In order to overcome this barrier, project stakeholders used different ways of engaging the users and explaining how the systems work. The idea of these educational campaigns was that the awareness would encourage behaviour change towards the more sustainable behaviour. "…habit and behaviour are not the same" however (Hodgson, 2007: 106), and "energy –consuming behaviours […] are often guided by habits, and … deeply ingrained habits can become counter-intentional" (Marechal, 2010: 1104). Therefore it is important to make users aware of their habits and convince them that change of habits could lead to financial as well as non-financial benefits, such as thermal comfort.

4.4 Impact on case study outcomes

Although classified in this paper into financial, governance and social barriers, often the actual experienced barriers do not fit precisely into a single category, and were categorised here for simplification. Experienced barriers frequently included elements of various categories, e.g. the large size of The Hague boilers - a problem due to the lack of finance, but it also due to the lack of information (governance/social) and lack of availability of appropriate alternative boilers (technical). Some issues, such as governmental policies, can either complicate the process of new energy initiative implementation and create a barrier, or can foster the project implementation and act as a driver. The Morris Model for example, was created due to new legislation supporting the PV market. Unlike the Morris Model, planning permissions in The Hague slowed down the process of project realisation, contributing to the dropout of one of the stakeholders and increased financial risk.

In addition, some barriers were interrelated whereas others were independent from one another. In The Hague, the original - and the most crucial barrier – was the drop-out of one of the stakeholders (governance), which led to a budget deficit (financial) -the other stakeholders therefore put significant effort into trying to find a financial substitute to cover this funding shortfall by inviting national government to take part in the project. This did not happen however, as the drop out of the stakeholder (a big utility company) had a negative effect on the projects' reputation. The financial gap was eventually covered by the main stakeholder and instigator of the project (Vestia) and the City of The Hague; this however required financial sacrifices on the technical side of the project and as a result smaller, cheaper and less efficient boilers were installed in the houses of the end-users (exacerbating the technical barriers). The under-sized boilers then became the main area for complaints from the end-users thus enhancing the social barriers. This example illustrated a domino effect, and although all the barriers were to some extent overcome, the outcome of the project might have being different if the first - governance barrier – had not occurred.

These case studies illustrate that governance barriers can play a crucial role in project implementation mainly because they affect the timing of the project. Timing is crucial as slight changes in the business environment can influence investment decisions: "It's expected that every major, prestige project has good environmental performance; that it's low energy usage and stuff like that. So I think the time for this [Kungsbrohuset] was perfect. We did a large marketing campaign and it was completely based around the environmental performance of the building. We'd never do that again now. That time is past" (Kungsbrohuset).

5 RECOMMENDATIONS

Dramatic change, such as a shift to DE, frequently faces a multiplicity of different barriers, and it is important to investigate strategies to overcome or mitigate them.

Governance was the greatest barrier in the cases presented here, which requires action not only from the project stakeholders but also from local and national government. In order to ease the regulatory barriers, the procedures of obtaining planning permissions should be simplified and more transparent. The enhancement of co-ordination, particularly within the different regulation authorities during the overall procedure of the project implementation could also lead to removing governance barriers. In addition, improvement of the overall acceptance by public and – importantly - politicians and decision makers of DE will lead to its wider use.

The actions taken by the stakeholders in order to overcome governance barriers should be aimed at enhancing already successful partnerships. Trust developed in previous projects can encourage transparency and improve the overall project implementation experience for all stakeholders, including end users.

Highly qualified specialists are crucial as the expectations on the performance will only be met if the installations are carried out properly and therefore often constant control is required. In addition to the constant supervision, the cost of the qualified labour is also high, increasing the overall cost.

In terms of overcoming financial barriers, a wide variety of policies including regulations, standards, property rights, permits, fees, subsidies etc. should be introduced to assure achieving the 80% target. Criteria for use of the policy instruments should include (but is not limited to) equity, efficiency, scientific validity, consensus, frugality and environmental effectiveness. In order to promote the appropriate use of financial, legal and social incentives, the regulatory reforms should be encouraged.

To help overcome social barriers, it is important to offer as much support as possible to end users, to explain the link between new technologies, ways of working and financial savings, as users frequently do not associate low energy consumption with financial savings. It is also important to make users aware of their own habits and behaviour, as behaviour change is very difficult to achieve unless end users strongly believe in sustainability and are prepared to adapt and change.

Information evenings and distribution of information was not always effective in these cases in changing users' perceptions and their understanding of new projects. Therefore it is important to specifically address the performance context of these habits using feedback as well as commitment measures, such as smart meters, as they address both barriers: they provide information to enhance understanding and increase the visibility of the consequences of changing behaviour on energy consumption. In addition, it should be kept in mind that users play an important role in technology development (Ornetzeder and Rohracher 2006) and technical improvement can be realised through the users' feedback.

6 CONCLUSIONS

The four case studies presented here are examples of DE projects, and despite the unfavourable economic situation in recent years, these four projects were all deemed overall 'successful' by the participants.

This outcome, however, was challenged through the process of the projects' implementations. The main barriers identified were: difficulties with funding and financing; unfavourable administrative conditions; organisation and management constrains; lack of acceptance and perception, all of which were non-technical and could hinder or delay the projects planning and implementation. Although in these four cases these barriers did not lead to project failure, they did have a negative impact, with governance barriers the greatest on project implementation (particularly on overall costs).

While financial barriers did not play the decisive role in these cases and present possibilities for future improvement rather than failure factors, these case studies help illustrate that innovative energy initiatives often require higher initial investment and a stronger financial background compared to more conventional energy projects. In addition, Users often associated DE with discomfort and/ or sacrifice rather than as a way of reducing energy consumption and costs. This often leads to the decisions which may not be economically rationale but are the matter of habit or lack of interest.

In order to develop effective strategies to overcome these barriers, it is important to look at the casual chain of connected barriers rather than on an individual barrier, as this helps the identification of how crucial the impact of the barrier is on the overall progress and outcome of the project, not just an isolated stage.

Although all projects and settings are different, the barriers described here also provide potentially valuable learning for the innovative development and initiation of renewable energy systems in a variety of wider countries and settings, not just the UK.

REFERENCES

Allen, S.R., Hammond, G.P. and McManus, M.C. (2008) "Prospect for and barriers to domestic micro-generation: A UK perspective", *Applied Energy*, 85: 528-44.

Bergman, N. and Eyre, N. (2011) "What role for microgeneration in a shift to low carbon domestic energy sector in the UK?" *Energy Efficiency*, 4 (3): 335-53.

Blumstein, C., Krieg, B., Schipper, L. and York, C. (1980) "Overcoming social and institutional barriers to energy conservation", *Energy*, 5: 355-71.

Chmutina, K. and Goodier, C.I. (2012) "Case study analysis of urban decentralised energy systems", In *Proceedings of the International Conference on Technology transfer and Renewable Energy, Mauritius*, pp. 501-16.

Chmutina, K., Goodier, .C.I. and Berger, S. (2012) "The potential of Energy Saving Partnerships in the UK", *ICE Energy, Thomas Telford, UK, ISSN: 1751-4223, E-ISSN: 1751-4231 (awaiting issue allocation).*

Coaffe, J. (2008) "Risk, resilience and environmentally sustainable cities", *Energy Policy*, 36: 4633-38.

Department of Energy and Climate Change (DECC) (2008) *Climate Change Act 2008*. Her Majesty's Stationery office, London, UK.

Goodier, C.I., Chmutina, K., Poulter, E. and Stoelinga, P. (2012) "The potential of seawater heating systems in the UK: examples of The Hague seawater district heating and Portsmouth Ferry Port", *Manuscript submitted for ICE Engineering Sustainability, Thomas Telford,* UK, *ISSN: 1478-4629, E-ISSN: 1751-7680.*

Government Office for Science (GOS) (2008) *Powering our lives: sustainable energy management and the built environment*. GOS, London, UK.

Hodgson, G.M. (2007) "Institutions and individuals: interaction and evolution", *Organisation Studies*, 28 (11): 95-116.

IPCC (2007) *Climate Change 2007: the Physical science basis – summary for policymakers*. Geneva. IPCC Secretariat. See www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf (accessed 07/09/12).

Jernhusen (2012). *Kungsbrohuset: Is your company ready?* See www.kungsbrohuset.se/Documents/ENG_KBH-broschyr_NYlogga.pdf (accessed 07/09/2012)

Marechal, K. (2011) "Not irrational but habitual: the importance of "behavioural lock-in" in energy consumption", *Ecological Economics*, 69: 1104-14.

Ornetzeder, M. and Rohracher, H. (2006) "User-led innovations and participants processes: lessons from sustainable energy technologies", *Energy Policy*, 34: 138-50.

Painuly, J.P. (2001) "Barrier to renewable energy penetration: a framework for analysis", *Renewable Energy*, 24, 73-89.

Pearlman, S.B and Scerbo, R.J (2010) "Public-private partnership for renewable energy: a case study", *New Jersey Law Journal*, CXCIX (10): 1-2.

Rydin, Y., Turcu, C., Chmutina, K., Devine-Wright, P., Goodier, C.I., Guy, S., Hunt, L., Milne, S., Rynikiewicz, C., Sheriff, G., Watson, J. and Wiersma, B. (2012) "Urban Energy Initiatives: the implications of new urban energy pathways for the UK", *Network Industries Quarterly,* 14: 2-3.

Shove, E. (1999) "Gaps, barriers and conceptual chasms: theories of technology transfer and energy in buildings", *Energy Policy*, 26 (15): 1105-12.

The City of The Hague (2009) *Sea water to heat houses in Duindorp*. See www.denhaag.nl/en/residents/to/Seawater-to-heat-houses-in-Duindorp.htm (accessed 07/09/12).

Verbruggen, A., Fischedick, M., Moomaw, W., Weir, T., Nadai, A., Nilsson, L.J.., Nyboer, J. and Sathaye, J. (2010) "Renewable energy costs, potentials, barriers: Conceptual issues", *Energy Policy*, 38: 850-61.