NEW DEPLOYMENT MODELS FOR MICROGENERATION:

Economic, Regulatory and Policy Issues in the UK

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Abstract

Microgeneration in individual homes has been the subject of increasing policy and industry attention in recent years. Whilst a recent study has stated that microgeneration could meet 30-40% of UK electricity demand by 2050, deployment to date has been slow. In its Microgeneration Strategy the UK government has started to outline how deployment could be increased. Various technical, economic, behavioural and institutional changes are needed to establish a market for microgeneration. This paper discusses how different deployment models for domestic microgeneration might attract investments in these technologies. It considers not only investments by individual households but also by energy companies. Based on an economic analysis of payback times for three different technologies (micro CHP, micro wind and PV) it identifies policy and regulatory recommendations. It argues for technology specific support policies in the short term. It also shows that a 'level playing field' for microgeneration technologies as a result of fiscal and market reforms could considerably increase the attractiveness of microgeneration technologies.

Keywords: microgeneration, deployment models, payback times, level playing field

1 Introduction

Domestic microgeneration, i.e. the generation of electricity (and heat) in individual homes, could contribute as much as 40% to UK electricity demand by 2050 (Energy Saving Trust, 2005b). Not only could it contribute to the reduction of household carbon emissions by up to 15% by 2050 (ibid.), but also enhance the security of supply due to energy generation close to the point of

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consumption and contribute to a more competitive energy market in the domestic sector. Incumbent energy suppliers or new energy service providers could offer microgeneration in the framework of new energy service packages and thus increase consumer choice while at the same time tackling fuel poverty[2]. This variety of drivers might explain why both policymakers and industry in the UK show increasing interest in microgeneration technologies.

The UK government published its Microgeneration Strategy in March 2006 aiming to remove barriers to microgeneration (DTI, 2006c). This strategy was backed by the Climate Change and Sustainable Energy Act 2006. Finally, the governmental Energy Review published in July 2006 underlined that the government would implement its Microgeneration Strategy 'aggressively' (DTI, 2006b: 69). At the same time major UK energy suppliers demonstrate increased interest in microgeneration technologies as a mean to establish long-term supply contracts with customers, improve the image of the company or reduce domestic demand.

However, deployment of microgeneration to date in the UK has been rather slow with only around 82,000 microgeneration technologies installed – out of which more than 78,000 are solar thermal heating systems (DTI, 2006c: 14). It is not yet clear whether microgeneration will fulfil its potential, and questions remain about its attractiveness to consumers and energy suppliers. The eventual outcome will depend on a number of technical, economic, behavioural and institutional factors.

This paper identifies regulatory and policy measures that could stimulate the market uptake of microgeneration technologies in the UK – particularly how these might improve payback times and overcome other barriers. It explores two different deployment models for investments in these technologies: an independent approach by homeowners (the 'Plug & Play' model) is compared to company driven energy service contracts for microgeneration (the 'Company Driven' model). The economics of each model is tested by analysing payback times for the initial investment in three microgeneration technologies: micro combined heat and power production (CHP), micro wind and photovoltaic (PV). The paper argues that the distinction of supply and demand as well as domestic and commercial power plants incorporated in many existing policies and regulations disadvantages investment in domestic microgeneration. It shows how a 'level playing field' could improve the economics of microgeneration if changes were made to fiscal policy and the settlement system.

The analysis recognises that economic payback is not the only factor that influences microgeneration investment decisions and that a short payback for microgeneration does not automatically mean that consumers will take up this option. Consumer decisions are affected by a range of other factors including risks, imperfect information, bounded rationality and a lack of access to capital (Chesshire, 2003; Sorrell, 2004). In the case of microgeneration, risks associated with future energy prices and the reliability of new technologies are particularly important. Imperfect information may result from the lack of reliable sources as well as insufficient understanding of energy efficiency measures. Constraints in time, attention and the ability to process information lead consumers to make decisions under 'bounded rationality'. Therefore, individuals rarely behave as rational economic agents and do not consider future savings or revenues fully (Oxera, 2005). Nevertheless, there is some evidence that economic barriers are amongst the most important impediments to microgeneration uptake by consumers and energy suppliers (e.g. Energy Saving Trust, 2005b).

The paper is structured as follows. The next section outlines different deployment models for domestic microgeneration technologies. Section 3 explores the methods, data and assumptions. Section 4 presents briefly the current UK policy and regulatory framework for microgeneration

[2] In the UK "a household is defined as being in fuel poverty where it would need to spend more than 10 per cent of its income on energy to maintain a satisfactorily warm home" (Ofgem, 2005).

technologies. The results of the economic analysis comparing investments under current conditions and under a 'level playing field' are presented in section 5, and are discussed in section 6. The paper concludes with some policy and regulatory implications.

2 Different deployment models for microgeneration technologies

Microgeneration technologies can be deployed in a number of ways with different roles for consumers and companies (Watson, 2004). The use of different deployment models for microgeneration technologies may increase the economic (and social) attractiveness of microgeneration. The deployment model chosen will depend on the investors' preferences, the regulatory and institutional framework as well as technical issues.

In this paper we focus on two models for deployment with different roles for consumers and energy suppliers. They are 'Plug and Play' and 'Company Driven', and represent two alternative models in terms of the consumer-supplier relationship, and the role each side might play.[3] Consumer involvement ranges from a passive role to a 'co-provision' role (van Vliet, 2004). The former role does not imply substantial changes in behaviour as a result of having microgeneration installed in the home. The latter sees consumers as becoming more active participants in the electricity system.

The 'Plug and Play' model is inspired by the idea that microgeneration might allow consumers to become partly independent of conventional energy suppliers. Under 'Plug & Play' the microgeneration unit is owned and financed by the homeowner; homeowners might choose to maximise their on-site consumption, if export rewards are low in order to reduce their electricity bill through lower consumption of imported electricity.

The 'Company Driven' model is based on the notion that in the long term companies might use fleets of microgenerators as a substitute for central power generation – i.e. as a virtual power plant[4]. This model involves a more passive consumer who only provides the site for the microgeneration unit, but it is owned by an energy service company (ESCO) or traditional energy utility. Under this arrangement the microgeneration unit is controlled remotely and operated according to the company's needs. This could help balance supply and demand, and to avoid buying electricity from the wholesale market.[5] Since this will be more of an option after a certain market stage and a sufficient number of units installed, in the short to medium term a company driven approach is more likely to involve the provision of domestic energy service packages based on microgeneration technologies.

Energy service contracts can play a central role to attract homeowners to microgeneration by overcoming already mentioned barriers such as consumers' lack of understanding, lack of access to capital and risk aversion linked to new technologies. Based on the definition by the DTI Energy Services Working Group[6], an energy service contract can but does not necessarily include the full upfront financing by the energy service provider. Given the initial rather high upfront costs of new

[3] 'Community Microgrid' would represent a third model which is not considered in this paper. At the community level it might be more efficient (in economic and environmental terms) to use technologies at a larger scale instead of in individual homes (e.g. CHP with community heating).

[4] For more information about an example of a 'virtual power plant' visit the homepage of the EU-funded project 'The Virtual Fuel Cell Power Plant' at: http://www.cogen.org/projects/vfcpp.htm.

[5] The scope for remote dispatch (start-stop) of the micro-generator depends on the technology: while micro CHP linked to sufficient hot water storage has a certain operational flexibility, PV and micro wind are less controllable since their output depends on the weather conditions.

[6] "Any activity […] taken by energy companies and/or other market actors which results in demonstrable and sustained savings of supplied/delivered energy in their customers' households and which includes the option of initial investment by other than the household or property owner."(Energy Services Working Group, 2003b)

technologies such as microgeneration a contribution by the homeowner to the upfront costs might be necessary to make it an economically viable option for companies.

Energy service contracts can take a variety of forms related to their scope and depth (what and how it is included), investment and finance as well as ownership and risk (Sorrell, 2005). The following box summarises aspects of energy service contracts for microgeneration.

Box: Energy service contracts for domestic microgeneration

Core aspects:
- Installation and commissioning of the unit
- Operation and maintenance

Potentially:
- Financing

With the following financing options:
○ Internal financing (capital provided by the contractor)
○ Lease financing

Domestic energy services have attracted increasing interest in the UK energy market and important barriers have been identified such as high transaction costs, low margins in the retail business and the 28 day rule that allows customers to switch their supplier every 28 days (Chesshire and Watson, 2000; Energy Services Working Group, 2003b; Energy Services Working Group, 2003c; Energy Services Working Group, 2003a; HM Treasury, The Carbon Trust et al., 2005; SDC/UKERC, 2006). Recent and expected changes in the UK market framework make it however an option for the deployment of microgeneration.

As a consequence of increasing average UK household energy bills by up to 57% between 2003 and the beginning of 2006[7] homeowners are more interested in microgeneration.[8] Instead of leaving homeowners to go for the independent 'Plug & Play' model suppliers might prefer to offer energy service packages for microgeneration technologies. Following increasing energy prices in March 2006 900,000 domestic customers switched their supplier which is the highest rate for four years (Ofgem, 2006a). The likely removal of the 28 day rule (Ofgem, 2006b: 10) will further encourage incumbent suppliers or new market entrants to develop new contracts that can attract new customers and retain existing ones for longer.

New business opportunities might open up for residential energy service packages. Given the very low margins in the retail business, energy suppliers are interested in extending their business. As one supplier put it in an interview with respect to offers around microgeneration units: 'the ability to build up a portfolio of other transactions with that customer is a big part of the equation. There's still an ongoing supply relationship but you could almost ignore that in terms of assessing the benefits of a long-term relationship and the opportunity of other products'.

Both deployment models have important consequences for how investments in infrastructures should be treated. Power plants will be situated in private dwellings so that the energy infrastructure will no longer be financed solely by corporate or public money. Having outlined the methodology and data of the analysis, the following section will show how existing policy and regulatory framework does not acknowledge this change in energy investment and its implications for the economic performance of microgeneration.

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[7] According to unpublished calculations by Energywatch.

[8] Various newspaper articles pointed at microgeneration technologies as one potential solution to reduce domestic energy bills (e.g. 'How to make home a powerhouse', The Observer, 23/10/2005, p.11). As a consequence of this increased media interest one supplier reported that 2,500 people have contacted them for more information without any additional marketing efforts.

3 Methods and assumptions

The paper uses two main approaches. First, it analyses the economics of microgeneration using a spreadsheet tool. Second, it discusses the results of this analysis in the context of some insights from a series of qualitative interviews to explore policy and regulatory implications.

The economic analysis summarised in the paper calculated payback times for microgeneration investments under the two deployment models discussed above. The calculations tested the impact of changes in policy, fiscal incentives and other regulations. It also explored the impact of possible investment cost reductions by 2016 for the ‘Plug & Play’ model based on a recent Energy Saving Trust study (Energy Saving Trust, 2005b). The results of the economic analysis were used to structure a series of interviews with a range of relevant actors that have a direct interest in microgeneration in the UK. These include representatives from industry, government institutions and trade associations.

Data used for the analysis was based measured domestic electricity and PV output data from field trials in Havant, UK. Simulations were used to generate output data for micro wind and micro CHP because sufficient real data is not yet available. Domestic electricity consumption data were taken from 4 different households with an annual consumption of around 7140 kWh (a household known as unit 4) 6050 kWh (unit 5), 3670 kWh (known as unit 6) and 2780 kWh a unit 7). The consumption data are quite different in terms of annual level of consumption and their consumption pattern and allow the sensitivity of results to different import and export ratios to be explored.

The micro CHP modelling is based on the assumption of a nominal electric capacity of 0.85 kW (associated with a nominal thermal capacity of 6 kW) and a maximum electric capacity of 1.2 kW (8 kW thermal). Heat generation between 0 and 6 kW generates a scaled electric output of up to 850 W electric, heat generation between 6 and 8 kW a scaled output of up to 1.2 kW electric and heat generation between 8 kW and 12 kW generates 1.2 kW electric output. The thermal efficiency is 85% as compared to a condensing boiler of 92%, with a heat to power ratio of seven.

Since heat demand is the driver for the power output of micro CHP, two different building types and three different building standards were used to model this technology. As building types a 2 bedroom bungalow and 4 bedroom detached house were used. The three building standards considered were: a) poor building with single glazing, b) poor building, poor double glazing and c) part L building, part L glazing. These generic building types were combined with the electricity demand data for units 5, 6 and 7 to model the heat requirement and calculate on-site consumption, import and export of electricity.

Micro wind data were calculated for different wind sites (Bahaj, Myers et al., in press). For this paper a 1.5 kW power curve were combined with wind data from different UK sites where the data are corrected for terrain and height to 7m above ground level. This is the likely height of most roof mounted micro wind turbines. The corrected average wind speeds vary between 2.81 m/s and 4.09 m/s and generated an annual output of between 560 and 1680 kWh.

Under ‘Plug & Play’, installation costs were assumed to be £9,000 for a 1.5 kW domestic PV system, £3,000 for micro CHP unit and £1,500 for a 1 kW micro wind turbine including 5% VAT. Since micro CHP will be a replacement investment for a broken-down boiler in most cases, an additional cost approach has been used. This means that the additional costs of micro-CHP above those for a replacement boiler are considered. Anecdotal evidence suggests that this additional cost should be between £500 and £1,500[9]. The upfront costs for company investment include a bulk purchase discount of 30% and exclude VAT (see also discussion below).

The impact of possible reductions in installation costs over the next 10 years have also been tested using the learning rate approach employed by the Energy Saving Trust market study (Energy Saving Trust, 2005b). These projections need to be treated with some care, and only provide one possible trajectory. They lead to following cost assumptions for 2016: for PV £2,477/kW and for micro CHP £2,120/kWe in 2016. For the additional costs approach used for micro CHP in this paper, it is assumed that the costs for a new condensing boiler remain relatively stable. Therefore, the additional costs for a micro-CHP unit in 2016 fall to between £220 and £1,220. Since many of our interviewees stated that our current costs for micro wind are already low, we have not applied learning rates as reported in the EST study. Instead, a modest decrease in costs to £1,000/kW in 2016 has been assumed.

The current electricity retail tariff for households is assumed to be £0.10/kWh. Where households bear the costs for gas, no higher gas consumption for micro CHP was considered since it was assumed that consumption would be equal or less than in the existing boiler and only slightly higher than in a new condensing boiler. Operation and maintenance costs were not included in the case of micro wind and PV although it is possible that future costs for inverter replacement could be significant. For micro-CHP, it has been claimed that maintenance costs would be similar to those for current boiler service contracts. Thus, it was assumed that households would not occur additional costs, whereas under an energy service contract the contractor would have annual O&M costs of £50 for a micro CHP unit.

For private investment a simple payback time analysis was used whereas a discounted cash flow analysis was applied to company investments in microgeneration technologies with a discount rate of 8%.

4 Economic, regulatory and policy framework for microgeneration in the UK – towards a ‘level playing field’?

The existing UK regulatory and policy framework for investments in energy generation technologies does not fully recognise the potential benefits of domestic microgeneration for the energy system. This section will first outline the existing framework and then show how it disadvantages microgeneration. It will then suggest changes in the tax system and settlement system to level the playing field.

4.1 Implications of existing regulations for microgeneration

The wholesale market price is the reference price for contracts for electricity output. Microgeneration units have to comply with the BSC to get access to wholesale prices. Currently, the UK balancing and settlement system is not prepared for the inclusion of microgenerated electricity[10]. Exports are only ‘spilled’ into the distribution network and are not included within wholesale market balancing. Due to its embedded character, microgeneration is likely to reduce the costs for grid operation and maintenance (Mott MacDonald, 2004). Suppliers that make contracts for distributed generation can profit from these benefits in terms of reduced grid charges. This was captured in the calculations under the ‘Company Driven’ investment approach.

[9] The range of £500 to £1500 is based on anecdotal evidence since it is hard to get comprehensive market data on replacement boiler costs.
[10] The so called P81 document includes settlement profiles for micro CHP and micro wind. According to information from our interviews these profiles are virtually not used by suppliers due to their inaccuracy.

In the current UK electricity market framework, for homeowners the most straightforward source of income from the microgeneration unit is to consume the generated electricity on-site, thereby avoiding imports. The output could also be sold to a supplier that provides export rewards. Payment for exports is currently at the discretion of energy suppliers, though this could become mandatory as a result of the Microgeneration Strategy (DTI, 2006b) and the Climate Change and Sustainable Energy Act 2006[11].

Additionally there are support policies in place that provide additional income for owners for microgeneration units. The Renewables Obligation (RO) provides access to ROCs for electricity generated from renewable energy sources but not for electricity from micro CHP. The minimum electricity generation to qualify is 500 kWh per year. The amount generated is then rounded up or down to the next full MWh. The ROC value in the analysis was set at a rather conservative level of £39.[12]

Generators of electricity from renewable energy sources and Good Quality CHP that are exempted from the climate change levy (CCL) receive Levy Exemption Certificates (LECs) for each MWh of power exported to the grid. The levy is fixed at 0.43p/kWh for electricity. It does not apply to the domestic and transport sector. LECs enable suppliers to avoid the payment of CCL if renewable electricity and Good Quality CHP output is supplied to non-domestic customers.

From April 2006, grant support for some technologies is available under the new Low Carbon Buildings Programme (LCBP). Tables 1 and 2 summarise the available current income streams considered in the analysis in the next section.

Tab. 1: Income streams considered for economic analysis of 'Plug & Play' under current conditions

Technology / ***Income stream***	**Micro CHP**	**PV**	**Micro wind**
LCBP capital grants	No	Maximum £3,000 per kWp installed, up to a maximum of £15,000 subject to an overall 50% limit of the installed cost (exclusive of VAT)	Maximum £1,000 per kW installed, up to a maximum of £5,000 subject to an overall 30% limit of the installed cost (exclusive of VAT)
Avoided electricity imports / reduced electricity bill	Electricity price of 10p/kWh		
ROCs	No	ROC price of £39/MWh[13]	
Export / generation rewards	Not considered in the baseline calculations since only available on a voluntary basis from some suppliers.		

The economic analysis for energy 'Company Driven' investments in microgeneration technologies compares three different energy service contract arrangements: first, the continuation of a standard

[11] http://www.opsi.gov.uk/ACTS/acts2006/ukpga_20060019_en.pdf
[12] This was the ROC auction price under Non-Fossil Purchasing Agency in October 2005. The third annual report on the RO by Ofgem gives an average ROC value of £45/MWh for 2004/05.
[13] ROC auction price under Non-Fossil Purchasing Agency in October 2005. The third annual report on the RO by Ofgem gives an annual ROC value of £45/MWh for 2004/05.

supply contract for micro CHP with an upfront payment by the consumer of £600; second, a lease contract with a regular lease payment and an upfront payment of £100 for micro CHP and micro wind and £1,000 for PV, the annual lease payment is £150 for micro CHP and micro wind and £500 for PV; finally, a contracting arrangement where the customer pays for the heat consumed instead of the gas delivered, but continues to pay the electricity bill (for micro CHP only) where the heat price is 2p/kWh and costs for gas for the contractor £0.01/kWh[14].

Tab. 2: Summary of company income from different microgeneration contracts

Supply contract	Lease contract	Contracting
Upfront payment	Upfront payment Lease payment	Heat purchase
ROCs Output at SBP / Embedded benefits Upfront incentives (e.g. bulk purchase discount of 30%)		

A reduced sales tax (VAT) rate of 5% rather than the standard 17.5% is available for microgeneration technologies in the UK. This only applies if the purchase does also include a service (e.g. the installation of the unit). Companies investing in certain energy efficiency measures have access to enhanced capital allowances (ECA). This means that they can write off 100% of their investment in certain energy efficiency measures against their taxable profits in the year of investment. Since main corporate tax in the UK is 30%[15] this means that investment costs can be reduced by this percentage.

4.2 An uneven playing field: fiscal treatment and settlement system

Some barriers for the take-up of microgeneration in the UK have been discussed extensively in the context of the Microgeneration Strategy, the Climate Change and Sustainable Energy Act 2006 and the Energy Review. A few of these barriers are currently being addressed such as:

- The process to receive ROCs shall be made easier;
- Planning regulations are being reviewed with the objective to give microgeneration units permitted planning permission status such as satellite dishes using the General Permitted Development Orders;
- Under the Climate Change and Sustainable Energy Act 2006 suppliers are expected to develop and implement a reward scheme for microgenerated electricity exported to the grid;
- An accreditation scheme building on the scheme in place for the LCBP will include products, installers and manufacturers;
- Guidance for local authorities to integrate targets for microgeneration in new developments where appropriate;
- DTI sponsored field trial on smart metering;
- Promotion of community energy projects;
- Government's and Ofgem's comprehensive review of incentives and barriers for decentralised energy generation;
- Extension of EEC to all microgeneration technologies and based on carbon savings instead of energy savings and potentially specific targets for microgeneration.

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[14] Gas price for contractor: 0.01262/kWh as payable by major UK power producers and of gas at UK delivery points 4th quarter 2005 (DTI, 2006a)
[15] http://www.hmrc.gov.uk/rates/corp.htm

Whilst these activities and the barriers they address are important, the following paragraphs will focus on another set of barriers that have hitherto not attracted very much attention: the fiscal treatment of microgeneration investments and the existing settlement system.

4.2.1 The fiscal regime

The implications of the existing fiscal regime for microgeneration investments have hitherto been widely neglected. Notable exceptions are the Energy Saving Trust's study on fiscal incentives for domestic investments in energy efficiency measures and the Assocation for the Conservation of Energy's work on fiscal instruments for the support of domestic microgeneration (ACE, 2005; Energy Saving Trust, 2005a).

We focus our analysis on the fact that the fiscal treatment of investments in energy supply infrastructure is heavily biased towards business investment in central power stations. While corporate investors can generally offset their upfront costs against their tax liability and can pass through VAT, individual taxpayers do not have access to tax allowances/credits and have to pay reduced VAT (Chesshire, 2003). This has major consequences on the economics of investments in microgeneration technologies.

Business investing in new plants or machineries can offset their investments against their tax liabilities in the form of capital allowances and consequently reduce their upfront costs. The standard capital allowance is 25% on the reducing balance basis over several years. On the demand side businesses have access to Enhanced Capital Allowances (ECA) under which they can offset 100% of the investment costs for energy saving or low carbon technologies[16] against their tax liabilities in the year of investment. For an average company with a profit tax of 30% this means that the actual investment costs are reduced by 30% in the year of investment.[17] The same treatment applies to expenditures under energy service contracts for *businesses*. While some CHP technologies are ECA approved, electricity generating microrenewables such as PV or micro wind are not.

As a result, the domestic sector is disadvantaged twofold: first, companies offering energy service contracts to domestic customers entailing investments in a microgeneration unit do not have access to capital allowances for these investments and are therefore less likely to offer such contracts to households.[18] Second, private individuals purchasing a microgeneration unit do not have access to capital allowances.

4.2.2 Settlement system

The settlement system is another important barrier and source of unequal treatment between central and decentralised power plants. While the power output from central power plants is priced at the real-time wholesale price on a half-hourly basis, homeowners' owning a microgeneration unit do not have access to the real-time of their exports. With the introduction of the additional P81 profiles it is now possible for suppliers to consider exports from microgenerators in the settlement system. These profiles are however not used very often due to the lack of accuracy. In the existing system all suppliers within one Grid Supply Point (GSP) benefit from exports since they are netted off their bill in relation to their supply share.

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[16] Energy saving or low carbon technologies must meet the eligibility criteria as outlined in the Energy Technology List to qualify for Enhanced Capital Allowances (ECA).

[17] ECAs were introduced in 2001 as part of the climate change levy package to support businesses' investment in energy saving and low carbon technologies. Besides a reduction of all employers' national insurance contribution (NIC) by 0.3% ECA was one instrument to recycle income from CCL back to companies.

[18] Under current regulations capital 'expenditure incurred on the provision of plant or machinery for use in a dwelling house' does not qualify for capital allowances, http://www.hmrc.gov.uk/manuals/camanual/CA23060.htm, 21/07/2006

4.3 Levelling the playing field

The following paragraphs will outline how a 'level playing field' for the fiscal regime and settlement system could look.

It has been argued above (section 2) that with an increased installation of microgeneration the distinction between supply and demand will be blurred. Microgeneration units will be part of the supply infrastructure but will at the same time reduce energy demand from the grid and potentially reduce demand due to awareness rising. A 'level playing field' in the tax treatment would therefore not distinguish anymore between demand and supply side and include the following changes:

- Individuals investing in microgeneration technologies have access to the same capital allowances as companies have;
- Enhanced capital allowances are available for microgeneration including electricity generating technologies as energy saving investment;
- Capital expenditure for domestic energy service contracts qualifies for capital allowances.

Homeowners' access to the same upfront tax incentives is of particular importance since they apply at least similar and often significantly higher discount rates[19] to energy related investments than businesses do. Domestic energy-related investment decisions in the context of microgeneration are likely to be based on implicit discount rates of between 10 and 30% (Hausman, 1979; Train, 1985). As a consequence, future income streams are perceived to lose their value rapidly as time passes, and upfront incentives are valued most. ECAs for private taxpayers' investment in microgeneration would therefore be an important stimulus for 'Plug & Play' deployment models.[20] Investing in microgeneration could reduce upfront investment costs reduced by 22% or 40% depending on the marginal tax rate. Nearly 10 million could claim this tax relief on their Tax Self Assessment return.[21] Alternatively a separate scheme could be set up or an approach similar to the existing 'salary sacrifice' schemes administered by employers could be used (see section 6 for more details).

Under current conditions output from microgenerators is not valued accurately. Suppliers' voluntary export reward schemes are more based on marketing aspects than on the pass-through of the actual export value. Our calculations in the next section show how a 'level playing field', i.e. microgenerators' access to half-hourly market prices would improve the economic attractiveness of investments. To do this, the System Buy Price as market price (SBP) has been used to value microgeneration output or exports based on 2005 prices.[22]

5 Economic performance of microgeneration and the influence of policy and regulatory changes

The economic analysis will first show the economic situation of microgeneration in the UK under current conditions and then explore how a 'level playing field' would improve the situation for both homeowners investing in microgeneration and companies investing in energy service contracts for microgeneration.

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[19] Discount rates are not equivalent of capital costs (i.e. interest rates), but reflect the valuation of future income from a capital expenditure. This can be influenced by high transaction costs, lack of information etc.

[20] ECA regulation would have to overcome the conventional distinction between demand and supply side. Electricity generating micro-renewables reduce demand for grid electricity and contribute to higher overall efficiency in the grid through electricity generation closer to the point of consumption.

[21] According to the National Audit Office out of nearly 35 million UK Income Taxpayers, nearly 10 million had to file Self Assessment returns in 2003-04, http://www.nao.org.uk/pn/05-06/050674.htm, 20/07/2006.

[22] HH SBP from 2005 was on average 4.2p/kWh. Generally SBP are higher than the wholesale market price. Average wholesale market price between June 2005 and May 2006 was however 4.5p/kWh (The Carbon Trust, 2006).

5.1 Plug & Play

Current conditions for homeowners investing in microgeneration are compared to the payment of export rewards of 5p/kWh and a level playing field where homeowners have access to enhanced capital allowances (40% for a high rate taxpayer), SBP for exports and are liable for income tax payments[23] on the income from their microgeneration unit.

5.1.1 Current economics

For micro CHP, payback times under current conditions depend on the price differential assumed as compared to the purchase of a new condensing boiler and the building type and standard. For a £500 price differential payback time ranges between 2 years (with a very high heat demand of almost 40,000 kWh per year) and 9 years (with a very low heat demand of around 7,000 kWh per year). For a £1,500 price differential payback varies between 6 years and around 20 years (for a heat demand of around 12,000 kWh[24] per year. The calculations for micro wind (1.5 kW) include 6 wind sites with an annual output of above 500 kWh which consequently achieve the threshold for earning at least one ROC. This shows that payback times are between 7 and 19 years under current conditions. For the 1.5 kW PV panel payback times vary between 35 and 48 years depending on the share of on-site consumption of the microgenerated output (see Fig. 1).

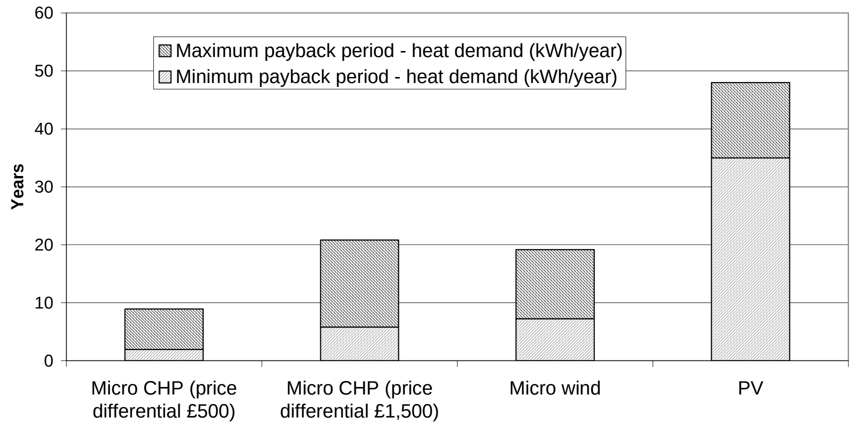

Fig. 1: Payback times under current conditions (incl. LCBP)

5.1.2 Level playing field

For micro CHP the analysis compares £500 and £1,500 price differential and provides a range of payback times for low heat demand (and low power output) and high heat demand (and high power output). Assuming a price differential of £1,500 Fig. 2 shows that a ‘level playing field’ even if income tax payment was included provides the most attractive framework for homeowners to invest in micro CHP. It more than halves payback times for the low heat demand from 21 years to 9 years for a 40% marginal tax rate payer. At a £1,500 price differential an export reward of 5p/kWh maximum payback time would be reduced to 14 years.

[23] Income tax payment is considered for income from the sale of ROCs and exports. Currently consumers do not have to pay income tax on these incomes. Under a level playing field it might however be argued that such an income tax payment has to be applied. Payback times presented here are therefore rather conservative estimates.

[24] The lowest heat demand for the £1,500 price differential is higher than for the £500 price differential since 2 bed part L compliant building was omitted due to very low heat demand and a payback time of above 25 years.

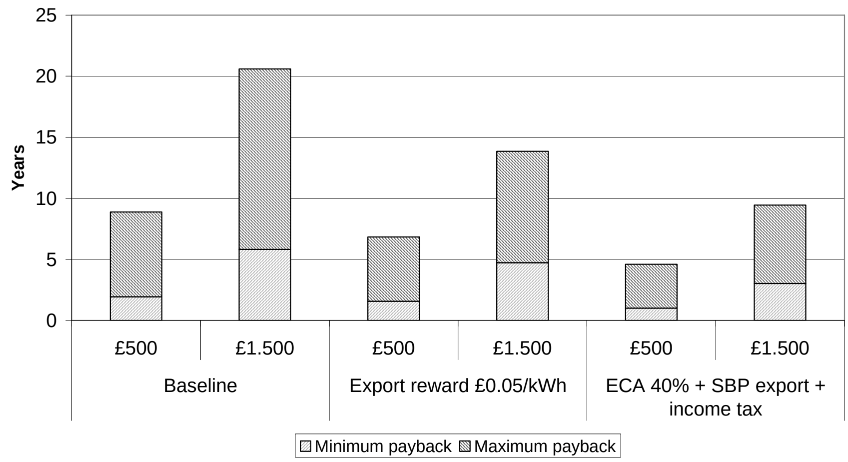

Fig. 2: 'Plug & Play': Level playing field for micro CHP comparing £500 and £1,500 price differential

A 'level playing field' would create the same investment conditions for a homeowner as under current conditions with access to LCBP grants for micro wind. The framework would be considerably more attractive (between 3 and 6 years) than under an export reward scheme of 5p/kWh without LCBP grants (see Fig. 3).

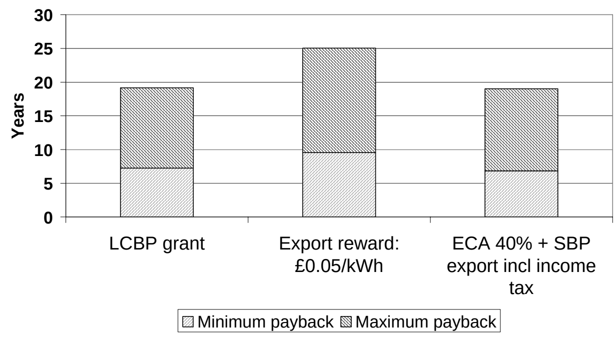

Fig. 3: 'Plug & Play': Level playing field for micro wind (1.5 kW)

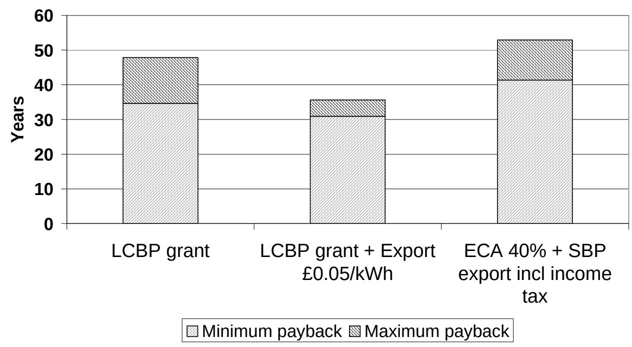

Fig. 4: 'Plug & Play': Level playing field for PV (1.5 kW)

In the case of PV a 'level playing field' does not improve payback time as compared to current investment conditions including the Low Carbon Buildings Programme. Export rewards of 5p/kWh are only a viable option for PV if they are on top of upfront incentives like LCBP. In this case export rewards can reduce payback time by more than 10 years.

If installation costs are reduced by 2016 as outlined in the EST report and if import tariffs were at 12p/kWh, investments in PV and micro wind could payback just about within the unit's lifetime without any additional support policies. PV would payback between 25 and 35 years, micro wind (1.5 kW) between 7 and 18 years. Micro CHP's payback times would improve marginally since the cost reduction potential is assumed to be rather low within the next 10 years.

5.2 Energy service contracts

For energy service contracts the analysis compares current conditions to a level playing field with access to capital allowances and a 10% increase in electricity prices as well as reduced costs in 2016.[25]

5.2.1 Current economics

For company investment in micro CHP two cases are compared: first, a 2 bed bungalow with an annual heat demand of around 18,000 kWh and annual power output of around 2,400 kWh and, second, a 4 bed detached house with annual heat demand of 31,440 kWh and an annual electricity output of around 3,800 kWh. Under the outlined assumption a 'standard' contract is not viable for the 2 bed bungalow and would achieve a positive NPV for the 4 bed detached house in year 10. The 'lease' contract would achieve a positive NPV in year 7 or 11, 'contracting' in year 8 or 20 (see Fig. 5 and 6).

For PV and micro wind only lease contracts were tested – in the case of micro wind for 2 different wind sites. This shows that under current conditions a lease contract for micro wind would reach a positive NPV after between 8 and 18 years. A 1.5 kW south facing PV installation would achieve a positive NPV in year 20 under the above assumptions (see Fig. 7 and 8).

5.2.2 Economics under a 'level playing field'

For a 2 bed bungalow access to capital allowances (Standard or Enhanced) can reduce payback times for micro CHP from above 20 years to 14 or 11 years respectively under a standard contract, from 11 to 8 or 7 years respectively under a lease contract and from 20 to 12 or 11 years respectively under a contracting arrangement. Similarly for a 4 bed detached home the year of positive NPV would be reached in year 6 or 5 respectively instead of in year 10 under a standard contract, in year 5 under a lease contract and year 6 or 5 respectively instead of in year 8 under contracting.

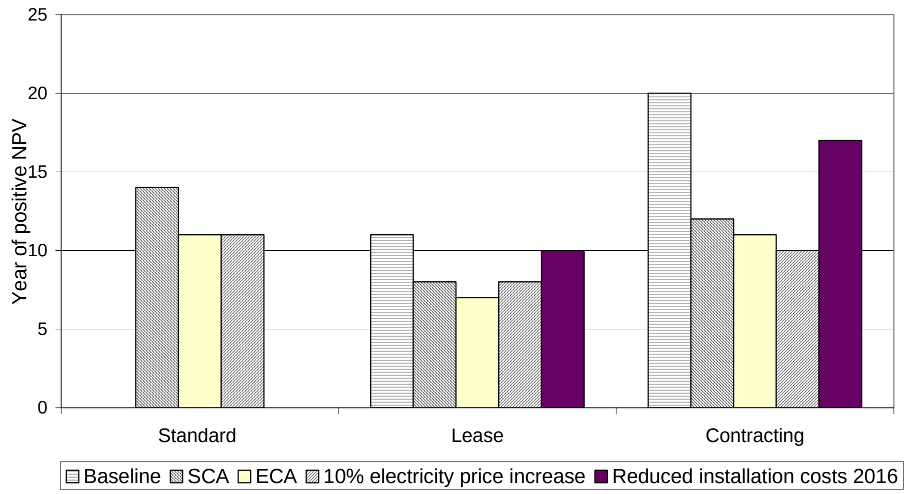

Fig. 5: Economics of micro CHP under company contract for 2 bed bungalow

[25] Payback calculations for ‚Company Driven' models do not include tax on the profits from the microgeneration contract because this would partly depend on the energy (service) company's overall cost structure. Within the scope of this project it was not possible to include this in our analysis.

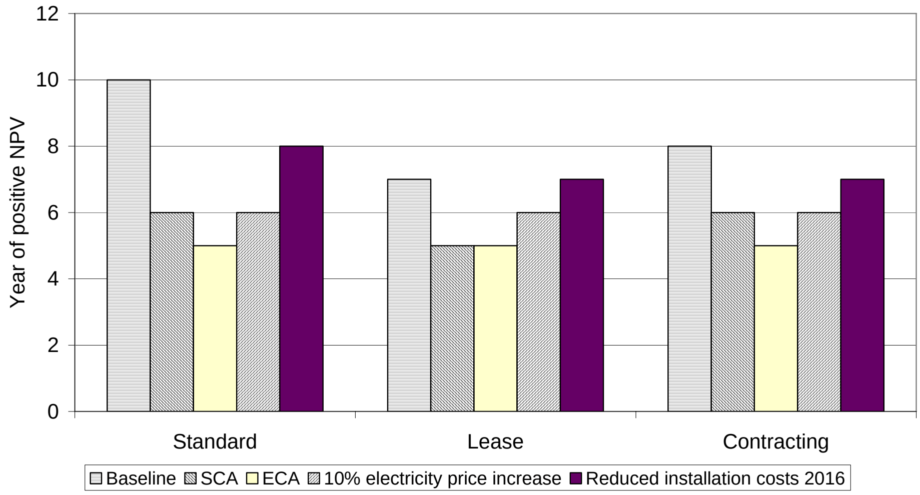

Fig. 6: Economics of micro CHP under company contract for 4 bed detached

At a good rural wind-site investment in a micro wind turbine would reach a positive NPV after 6 (SCA) or 5 (ECA) instead of 8 years. PV's positive NPV would be reached in year 7 (ECA) or 12 (SCA) instead of year 20.

The two other scenarios – increasing electricity prices and reduced installation costs in 2016 – also provide more attractive investment conditions for domestic microgeneration. A yearly 10% electricity price increase would lead to similar conditions as under ECA for a 2 bed bungalow and as under SCA access for a 4 bed detached home. In the case of micro wind such an increase would also lead to similar conditions as for ECAs. Reduced installation costs have the greatest impact for PV and micro wind.

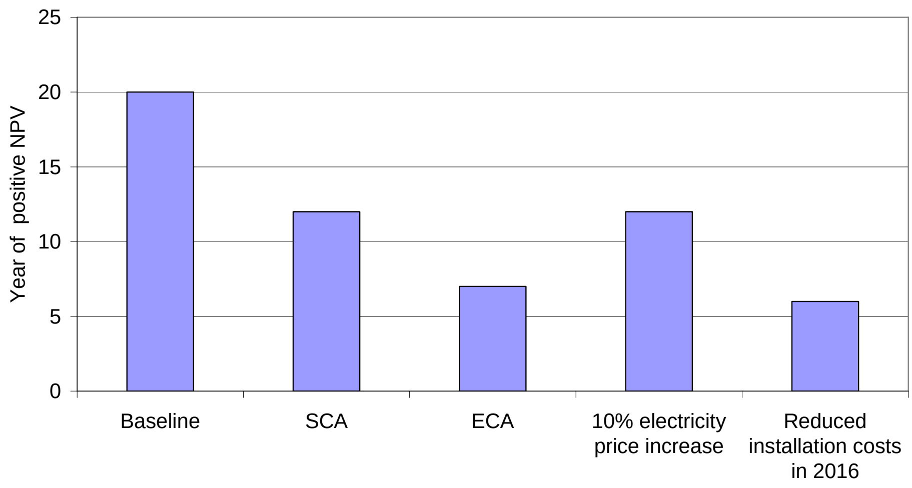

Fig. 7: Economics of PV (1.5 kW, south facing) under company contract

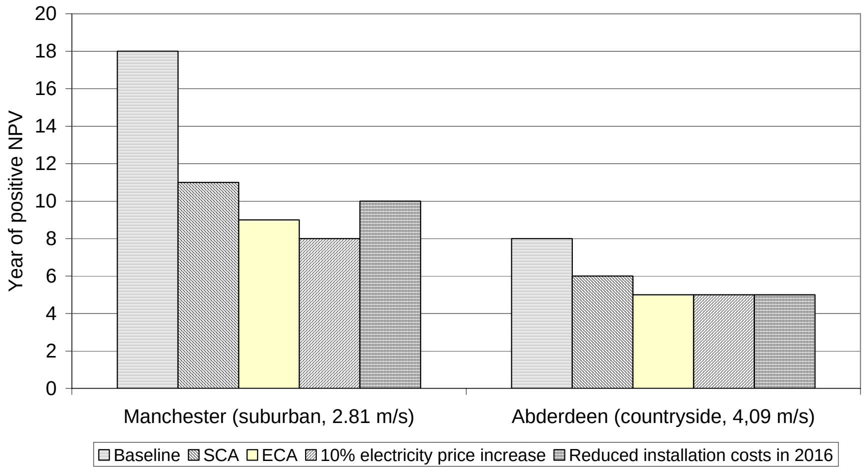

Fig. 8: Economics of micro wind (1.5 kW) under lease contract comparing suburban and rural wind-site

6 Discussion of results

The analysis examined the extent to which each deployment model will be affected by different policy and/or regulatory arrangements. It shows that under a consumer-led deployment model, there is a particular need to guarantee a fair reward for electricity exported to the grid so that individual microgenerators have access to the value of the microgenerated output (including the embedded benefits) to the electricity system. This will consequently require changes in the settlement system to allow energy suppliers to fully include microgeneration output. Both approaches – company and consumer driven – will benefit from changes in the fiscal regime. If homeowners had access to the same tax allowances as companies and to the market value of the exported electricity to the grid, this would considerably improve payback times or keep them at similar levels as under the LCBP. This is the case even if consumers have to pay tax on income from power sales.

Households have already had access to various tax breaks similar to that proposed here, although these are not called ‘capital allowances’. Tax breaks have been available for various domestic goods and services such as home computers (abolished in the Budget 2006), mobile phones, cycles and childcare. As an alternative to enhanced capital allowances for households, schemes like the ‘salary sacrifice’ scheme[26] could be extended to microgeneration. Employees might be able to build up a ‘Green Fund’ by directing part of their salary directly into a fund which they must use after a certain period of time for investments in ‘green’ technologies (e.g. microgeneration). Such schemes could be financed using funds from the Environmental Transformation Fund (DTI, 2006b: 15) or the Non-Fossil Fuel Obligation (NFFO) fund[27].

The Budget 2006 identifies as one long term policy goal to address ‘environmental challenges, such as climate change and the need for energy efficiency in response to rising oil prices’ (HM Treasury, 2006: 3). It acknowledges that short-term considerations and market failures can prevent businesses

[26] Under a ‘salary sacrifice’ scheme the „employee gives up the right to receive part of the cash pay due under his or her contract of employment. Usually the sacrifice is made in return for the employer’s agreement to provide the employee with some form of non-cash benefit” (HMRC, http://www.hmrc.gov.uk/specialist/salary_sacrifice.pdf#search=%22hmrc%20salary%20sacrifice%20scheme%22). The employee benefits from lower tax payments and NI contributions, the employer saves NI contributions.

[27] When th Renewables Obligation (RO) was introduced in 2001 already existing renewable energy sites built under the NFFO were included in the RO. The surplus benefits generated went into the NFFO fund administered by Ofgem. Over the period to 2010 this fund is expected to be between £550 million and £1 billion, while only £60 million are so far earmarked for the promotion of renewable energy (National Audit Office, 2005).

and households from investing in cost-effective sustainable measures and that fiscal instruments can play an important signalling effect to correct some of these failures. This was also pointed out in the Energy Review: “the principle that fiscal measures can play a part in achieving our environmental goals has been established” (DTI, 2006b: 131).

Besides changes in the fiscal regime, a ‘level playing field’ would require major changes in the UK settlement system to allow microgenerated output to be included. This could be implemented on the basis of profiles or half-hourly metering. Currently profiles seemed to be favoured in the UK due to lower transaction costs (less data collection and aggregation is required). The usage of profiles would however require more than one profile for each technology – in particular for micro wind and micro CHP since both technologies are heavily dependent on the installation site. Wind speed and domestic heat demand vary considerably. Thus the costs for the establishment of and maintenance of enough profiles might be high.

The installation of advanced ‘smart’ meters is an alternative approach[28]. This would not only generate accurate site-specific data that could be fed into the settlement system. It would also open up a broader agenda of possibilities for demand management and consumer engagement. Better information about prices and consumption could be relayed to the consumer in real time. Investments in new meters would however require a major initiative by the government and the regulator Ofgem. Under current regulations (e.g. ‘28 day rule’) the risk of stranded investments is too high for suppliers to actually invest in new meters without additional incentives.

7 Conclusions

This paper has analysed how the attractiveness of investments in microgeneration technologies can be improved from an economic perspective. It has focused on two investment approaches. One deployment model assumed that individual homeowners would invest in microgeneration. The second model was company driven, where energy suppliers or energy service companies offer microgeneration packages to their customers, e.g. in the framework of a leasing or contracting arrangement. A central underlying assumption has been that shorter paybacks should lead to higher levels of microgeneration investment. However, it is not yet clear how short payback periods will need to be for consumers or energy companies to invest significantly in microgeneration. Payback periods are only one factor that influences consumers’ decision to invest in microgeneration technologies.

The three technologies considered – PV, micro CHP and micro wind – have considerably different features in terms of installation costs or annual output. This is reflected in the economic paybacks of these technologies.

For a ‘Plug and Play’ investment approach of an individual household under current market conditions including a grant from the Low Carbon Buildings Programme, payback times for a typical PV system are still measured in several decades. Payback times for a micro wind turbine can be well below 20 years if output is above a certain threshold, and can therefore fall within their technical lifetime. Micro wind turbines are best situated in areas with a good wind resource. These are more likely to be in rural locations than in urban areas, but the performance of individual installations will be heavily dependent on site-specific geography.

As opposed to the two other technologies that are ‘new’ or additional technologies for the vast majority of households, micro CHP will in most cases be an alternative to the purchase of a replacement boiler. It seems therefore reasonable to use the additional costs. The premium for a micro CHP is not yet easy to determine, so a range of £500-£1500 has been assumed here.

[28] The recent announcement of a £5m smart metering field trial in the UK is a first step towards this.

Depending on the heat demand and electricity consumed on-site, a payback period of 10 years or less is achievable.

For all technologies these payback times are still too long in most cases. We have therefore tested which changes in policy or regulation might improve this position. These changes will help build consumer confidence and to test novel microgeneration technologies in sufficient numbers. If the technologies live up to expectations, these incentives will also help to grow the market, and potentially, to bring costs down.

A system of export rewards with a flat fee per kWh improves the economic attractive particularly of micro CHP and PV but should only be used as short-term solution in the transition towards a 'level playing field' in the fiscal treatment and settlement system. Tax allowances would provide a longer term incentive for investors and industry. Furthermore, upfront incentives such as tax allowances are more attractive for individuals since they value upfront income considerably more than future income.

Changes in the tax system in order to treat the investments on the demand and supply side of the energy system in the same way could be introduced instead of capital grants. Tax incentives are already available for some investments in energy efficiency technologies in the form of enhanced capital allowances for businesses. The same allowance for household investments in microgeneration would allow them to write off 100% of the investment costs against their taxable income. Depending on their marginal tax rate this would mean that 22% or 40% of the investment costs would be recovered in the first year. In contrast to capital grants the regressive impact of capital allowances would lead to a certain inequality in terms of support. In the absence of special provisions for those on low incomes, this may conflict with the attainment of other energy policy objectives such as the reduction of fuel poverty. At the same time it could trigger investments among high income groups who are more likely to include 'first movers', and therefore contribute to the creation of a volume market. For assumed technology costs in 2016 this would lead to payback periods for consumers within the lifetime of the technology in the case of micro wind and PV.

Energy service contracts for microgeneration could help to overcome different barriers for individual households' investments such as lack of access to capital or risk-aversion about new, unproven technologies. Access to capital allowances for investments in domestic premises would help to make it a business opportunity for energy companies and attract new energy service companies to the market.

Microgeneration could also provide an impetus to upgrade domestic metering. The costs for new meters are rather small when compared to overall microgeneration investment costs. Regulations for new meters should therefore consider potential future requirements. This means that the installation of import, export and generation meters should be the minimum requirement for new microgenerators since this would allow consumers to access a full range of incentives. Going one step further, 'smart meters' that also include half-hourly data collection and user-friendly display systems might also be mandated. This could increase the potential benefits of microgeneration by making it more likely that consumers will change their behaviour.

Overall, it is crucial that policy and regulatory measures do not only focus on the economic perspective considered in this paper, but also respond to other barriers to the uptake of microgeneration. The Microgeneration Strategy shows that there is already some recognition of this within government, but more needs to be done. The decision-making criteria used by consumers who consider investing in energy efficiency measures or in microgeneration are complex. Economic criteria are important in most cases, but they are evaluated alongside many others including risk, aesthetics, the experiences of friends and colleagues, the 'hassle factor', the need for planning permission and the availability of well-trained installers. Some of these additional criteria can be partly addressed using the policies and measures discussed in this paper, whilst others will need to be tackled by complementary approaches.

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