The Economics of Micro-Generation: Case Studies from the UK

*By Jim Watson**

In recent years, three dominant trends have emerged in the energy supply industries of many industrialised countries. The liberalisation of electricity and gas markets has been accompanied by vertical de-integration into generation, transmission, distribution and retail supply. Environmental regulations have been tightened in response to issues such as acid rain and climate change. There has also been a renewed preoccupation with security of supply, both in its operational sense (the day to day security of energy networks) and its strategic sense (the adequate availability of energy resources).

Partly in response to these trends, there has been an increased interest in distributed electricity and heat generation as new electricity generation, power electronic and information technologies emerge. One of the most radical implications of the expected growth in distributed generation is the possibility of micro-generation in individual homes. If it catches on, micro-generation will fundamentally change the relationship between energy suppliers and consumers. As Amory Lovins points out in his recent book *Small is Profitable*, 'technological, conceptual and institutional forces are … driving a rapid shift towards the "distributed utility" where power generation migrates from remote plants to customers' back yards, basements, rooftops and driveways'.

By blurring the traditional boundary between energy supply and demand, micro generation presents utilities, regulators, consumers and equipment suppliers with a new set of challenges. Its advent has, therefore, attracted the attention of governments and energy companies alike. The International Energy Agency's recent review of this issue shows that policies are being developed in many countries to encourage renewable energy technologies and combined heat and power systems. To support these policies, work is also underway to rethink and reshape the way in which energy networks are structured and regulated.

Alongside these government initiatives, some of the world's largest energy companies have seized the opportunity to move into distributed and micro-generation technologies. The most notable example is the decision by ABB, the Swiss-Swedish engineering giant, to abandon its roots in large scale power generation to concentrate on decentralised sources such as wind power and micro turbines. Similarly, the world's biggest corporate takeover attempt – of Honeywell by General Electric in October 2000 – resulted in the acquisition of Honeywell micro-turbine and fuel cell technologies by GE. It is no coincidence that two of the world's largest oil companies – BP and Shell – are now amongst the world's top five developers of solar photovoltaic technologies.

This article focuses on some of the key economic challenges that will confront micro-generation technologies during the next few years. It investigates the economics of micro-generation investments in the UK, based on solar photovoltaic (PV) and domestic combined heat and power (micro-CHP) technologies. In its recent energy White Paper, the UK government confirmed that it expects these two technologies to make significant contributions to the energy system by 2020. It is, therefore, interesting to assess what incentives there are for householders and energy companies to invest in these technologies, and what barriers might prevent such investments.

Models for Financing Micro-Generation

The eventual size of the micro-generation market in the UK and other countries will depend on a number of factors including the availability of technologies, the costs and benefits of installation and the complex array of regulations that govern the energy system. Economic incentives of various kinds will have a key influence on decisions to invest in micro-generation by householders, energy suppliers or energy service companies. At present, it is not clear which of these potential categories of investor will own the majority of micro generation units, and how these units will be operated and maintained.

Some Alternative Approaches

There are a number of ways in which micro-generation units could be financed, owned and operated in the future. Table 1 summarises the key features of three possibilities and their implications for both householders and energy suppliers.

Table 1
Three Models for Financing and Operating Micro-Generation

	Plug and Play	Company Ownership	Leasing
Ownership	*Householder*	*Energy Supplier*	*Energy Supplier:* But possible transfer to Householder at end of leasing period.
Operation	*Householder:* Operation according to Householder needs for power and heat	*Energy Supplier:* Operation to help Energy Supplier balance supply and demand (could take into account Householder preferences)	*Shared:* Operation to help Energy Supplier balance supply and demand, taking into account Householder preferences
Costs and Benefits	*Householder* saves on energy bills, but has to pay capital cost.	*Householder* gets cheaper energy in return for hosting micro-generation.	*Householder* saves money on energy bills, and spreads capital costs.
	Energy Supplier loses kWh sales, and has to provide clear terms of grid access and buyback rates.	*Energy Supplier* avoids buying wholesale electricity, and can balance their system more cheaply	*Energy Supplier* retains some operational control and recoups capital investment through lease payments.

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Whilst the table does not cover all possibilities, it includes different options for ownership of the micro-generation unit, its operation and the financial costs and benefits for the consumer and the energy supplier.

The first 'plug and play' model is the simplest. It is probably the most common method for financing micro-generation installations at present. The household consumer pays for a micro-generation system (e.g., a micro-CHP or solar PV installation), and operates it to maximise their private economic benefits. Depending on the country in which these systems are installed, the up-front capital costs may be partly reduced through grants, tax breaks or loan schemes.

The second model is more complex, particularly because it requires remote control of the micro-generation unit by an energy supplier. It is already being considered by some energy companies. For example, the local electricity company in Hamburg, Germany intends to install 50 micro-generation fuel cell units that it will control remotely in this way. Under this model, there might be some kind of benefit sharing with the householder (e.g., in the form of lower energy bills).

The third financing model is an intermediate one. The micro-generation system is leased to the householder over a number of years by an energy company. Costs and benefits are shared, as is the day-to-day control of the unit. One possibility is for the householder to set their priorities for heat and electricity in advance. These priorities would then be taken into account by the energy supplier when it operates the facility. In common with the second model, communication and control signals could be passed between the consumer and the energy supplier.

Implications for the UK Energy System

When applied in the context of the UK energy system, these models for investment in micro-generation raise a number of important issues. To explore these issues in some detail, it is useful to test the models using those micro-generation technologies that are likely to be available commercially in the next few years. Solar PV and micro-CHP are good examples. Grants for domestic solar PV installations were introduced by the UK government over a year ago in an effort to catch up with established initiatives in Germany, the USA and Japan. For micro-CHP, at least two companies are planning to launch new products in the next year or so. One of these companies – PowerGen – expects that 30% of UK households will have a micro-CHP unit by 2020.

A central issue for the evaluation of these technologies is the extent to which different models for ownership and operation will alter the economics of investing in micro-generation. For example, the financial rules that govern energy investments by consumers are different to those that apply to investments by energy companies. As a result, the Plug and Play and Leasing models for investment are subject to different rules for UK sales tax (known as Value Added Tax or VAT) and tax investment allowances.

The Economics of Plug and Play

To illustrate some of the factors that affect investments in micro-generation in the UK, Table 2 compares the economics of a micro-CHP system and a solar photovoltaic (PV) system. In each case, the system is purchased by the householder using an available (or almost available) technology and operated on a 'Plug and Play' basis.

Table 2
Economics of Solar PV and Micro-CHP Investments by Householders

	Solar PV Solar Century Sunstation 12	**Micro CHP** BG Stirling Engine
Size	$1.5kW_p$	$1.1kW_e/5kW_{th}$
Installed cost to consumer	£4300 + 5% VAT*	£2500 + 17.5% VAT
Annual electricity generation	1100kWh	2700kWh (500kWh exported)
Electricity price (buy & sell)	7.5p/kWh	7.5p/kWh
Annual gas consumption	-	19050kWh
Gas price	-	1.5p/kWh
Annual ROC revenue**	£45	-
Payback period	**35 years**	**14 years**

Notes:
Calculations assume an average medium sized energy consumer, consuming 3300kWh of electricity and 19050kWh of gas, with net electricity metering.
* Assumes a 50% capital grant paid under the Department of Trade and Industry's current subsidy scheme.
** ROC revenue from the sale of Renewable Obligation Certificates at an average price of 4.0p/kWh.

The figures in the table give a rough idea of the economics of two micro-generation technologies, and some approximate investment payback times for householders. It is clear that, even with the current 50% capital grant scheme, solar PV still has a payback of several decades. The situation for Stirling engine micro-CHP technology is more attractive, though the payback period for this technology is still much too high to attract widespread interest.

These results are somewhat more pessimistic than those from some other assessments, particularly of micro-CHP investments. In a report to the Energy Savings Trust, EA Technology gave a much shorter payback period for these investments of 3-4 years. The difference may be explained by the fact that the EA Technology calculations are based on the marginal capital cost of micro-CHP (i.e., the difference between the cost of a CHP unit and the established alternative – a replacement central heating boiler). This type of comparison shows the premium that consumers would have to pay to upgrade to a micro-CHP unit instead of a condensing boiler. It is applicable only in circumstances when the consumer is forced to change their boiler due to a breakdown of their existing system. Whilst this scenario is expected by manufacturers to be one of the main drivers for micro-CHP in the UK, this marginal payback approach makes it difficult to compare micro-CHP economics with those of other technologies such as solar PV.

Barriers to Plug and Play

There are a number of economic issues related to the analysis in Table 2 that may inhibit the diffusion of 'plug and play' micro-generation in the UK and other countries. First, it is particularly important to note that the calculations in Table 2 do not include maintenance costs. These are likely to be significant, and at least as high as those for current central heating systems. Commercial maintenance packages for these systems currently cost consumers between £100-£150 per year. If maintenance costs of £100 per year are included, the payback period for a micro-CHP investment increases to 25 years. However, it is likely that most purchasers of micro-CHP units will be replacing an existing central heating boiler. Therefore, they will not incur significant *additional* costs for annual maintenance and servicing. For the second case – solar PV – manufacturers claim that maintenance costs will be close to zero since installations are designed to be maintenance free during their lifetime. It remains to be seen whether this will be the case in practice.

Second, the data in Table 2 for the solar PV case assumes that such installations will be eligible for Renewables Obligation Certificates (ROCs) that are issued to renewable generators in the UK. Since April 2002, ROCs have been issued to electricity companies for each unit of renewable electricity they produce. Registered suppliers have to use these ROCs to prove that they have generated or purchased a proportion of their electricity from renewable sources. Initially, this proportion has been set at 3%, though the figure will rise each year to reach just over 10% in 2010. If a supplier is unable to meet this target in a given year, they can pay a fine of 3p/kWh for any shortfall. In principle, householders should be able to accumulate ROCs for solar PV and other renewable electricity they generate, and sell these to suppliers with a shortfall. In practice, the transaction costs of doing this are expected to be high. At present, it is not clear whether householders will be able to aggregate their PV output to overcome these transaction costs. If ROC revenue is not available, the payback period for solar PV micro-generation in Table 2 would increase to 54 years.

A third significant economic qualification to the data in Table 2 concerns net metering. It is assumed in each case that net metering agreements with the local electricity supplier are possible. These mean that the householder exports and imports electricity at the same price (around 7.5p/kWh). In many cases, electricity suppliers are unwilling to offer net metering, and will instead buy electricity exports at much lower prices. For the micro-CHP case, a lower tariff of 3p/kWh for electricity exports would slightly increase the payback period to 15 years.

Whatever buy-back tariffs are ultimately available to householders, new two-way electricity meters will be required to allow the accurate calculation of their electricity bill. Some types of meter could also bring additional benefits to consumers. For example, they could allow householders to access variations in energy prices at different times of the day. Exporting at a time of high electricity demand could bring greater financial rewards, and help to change consumer behaviour in a way that benefits the whole electricity system. Another related possibility is that a householder could benefit from locational charges for the use of the electricity distribution system. The UK is currently in the process of implementing a new charging structure for the use of distribution networks to bring it more into line with the practice in other countries. One possibility is that householders would receive a payment from a distribution company for installing generation that would strengthen a weak part of the electricity network.

In addition to these potential economic barriers to ‘plug and play’ micro-generation, there are also technical and regulatory issues that could deter householders from making such investments. Many of these are now being addressed in the UK within a government-industry body known as the Distributed Generation Co-ordinating Group (DGCG). One of the most important issues considered by the DGCG concerns technical connection standards. These require equipment to be installed to protect the electricity network and the micro-generation system in the event of system instability or faults. A new standard – known as G83 – has now been developed to specify what is required with the aim of ensuring that electricity distribution companies do not have to inspect the installation of each micro-generation unit on a case by case basis.

The Economics of Investment by Energy Service Companies

For the Company Ownership and Leasing investment models (see Table 1), energy companies in particular will have to weigh up a different set of costs and benefits to those that apply to the Plug and Play model. On the positive side, it is probable that an energy company would be able to ‘bulk buy’ micro-generation equipment and achieve substantial discounts on the usual retail price. They would also be able to use standard capital allowances to offset part of their investment costs against their tax bill. Under current UK corporation tax rules, these allow 25% of the investment costs to be offset each year on a reducing balance basis.

The extent of the bulk buy discount is difficult to predict. As an example, it could be assumed that this will reduce the micro-generation installed cost by around a third. This is illustrated in Table 3 using the micro-CHP case. A hypothetical bulk buy discount at this level brings the installed cost down from £2500 to £1667 (plus 5% VAT). A further discount over the lifetime of the micro-CHP unit will be forthcoming from the use of capital allowances.

Table 3
Possible Features of Energy Service Company Micro-CHP Investment

	Micro CHP BG Stirling Engine
Size	$1.1kW_e/5kW_{th}$
Installed cost	£1650 + 5% VAT (33% discount by bulk purchasing)
Capital allowance discount	£130 in year 1, £97 in year 2, £73 in year 3 etc.
Discount rate	12%
Annual electricity generation	2700kWh (500kWh exported)
Annual electricity consumption	3300kWh (average medium consumer)
Electricity price to ESCo	5.0p/kWh
Annual gas consumption	19050kWh (average medium consumer)
Gas price to ESCo	1.0p/kWh
Annual income from consumer	£432 (10% discount on previous energy bills)
Payback period	**12 years**

Notes: Calculations assume an average medium sized energy consumer – 3300kWh of electricity per year and 19050kWh of gas, with net electricity metering. They also assume that energy service companies will be able to buy gas and electricity a third cheaper than individual consumers.

Despite this reduction in investment costs, each household installation would still require an energy company to invest around £1500 up front – an investment that it would have to recoup through consumer leasing payments, capital allowances and other savings. As Table 3 illustrates, one possibility would be that the energy company would agree to discount the consumer's total annual electricity and gas bills by a small percentage (say 10%) for a number of years. The installation of a micro-CHP unit would allow the company to offset some of its own electricity purchases (from the wholesale market) and to 'bundle' a number of services together – electricity, gas and micro-CHP maintenance – for a single annual charge. As the deregulated energy retail markets in many countries have shown, many energy companies are already bundling a number of products in this way to cut costs and make a profit.

As Table 3 illustrates, the economics of energy company investment in micro-generation using a leasing model are poor under present UK conditions. Assuming that the electricity and gas required for the household could be purchased at a 33% discount by the energy company, the payback period for this investment would be around 12 years. This is a substantial period of time, and is much too long for most companies to consider. It is possible, however, that it could be cut further if an energy company could find ways of reducing electricity, gas or micro-CHP equipment purchase costs still further. Alternatively, the company could offer customers a smaller discount on their bill.

Barriers to Leasing

Even if they were able to achieve further savings in costs, leasing investments by an energy company would still be difficult in the current UK market. One critical issue that is often cited in discussions of energy service approaches to investment is known as the 28 day rule. This allows consumers to switch electricity or gas suppliers by giving 28 days' notice to their current supplier. This rule is a cornerstone of the UK approach to energy deregulation, and is designed to protect consumers from 'lock-in' to high tariffs by suppliers. The problem is that the rule also makes it difficult for suppliers to offer energy service packages that depend on a relationship that is more than 28 days long.

Another issue that might impact on the attractiveness of micro-generation leasing or ownership by energy companies is information technology. New information technology investments might be desirable under these models to allow data and control signals to be passed between houses and energy companies. This would enable a much greater degree of co-ordination of household energy services by companies and consumers. However, it also implies a need for additional costly equipment and systems to interface consumer preferences and energy company requirements for balancing supply and demand. The cost of investing in this equipment may, however, be offset by the benefits to the energy company of being able to use a portfolio of micro-generation to help manage the operation of their network. As mentioned previously, the expected reform of distribution network tariffs in the UK could bring positive financial benefits for some micro-generators. In addition, a distributed micro-generation fleet could help a company to avoid paying for high-cost peak electricity. The aggregate effect may be to justify the costs of control and communication infrastructure.

Conclusions

This article has examined some of the key issues affecting the economics of micro-generation investment in the UK. In all cases except the forced purchase of micro-CHP due to central heating boiler breakdown, the payback time for such investment is over 10 years – too long for it to be justified purely on economic grounds. Of course, as demonstrated by the significant numbers of applications for the UK solar PV grant scheme, some consumers will wish to invest in micro-generation irrespective of the economics. Other factors, such as the desire to be a 'green consumer', the prestige of owning new technology, or a wish for energy autonomy might also be important.

The unattractive economics of micro-generation under current conditions are partly due to significant discrepancies in the tax rules for householders, energy companies and other parts of industry. To overcome this, it might be desirable to move towards a more level playing field. For example, if householders had access to the same tax allowances for energy investments as companies, payback times could be reduced considerably. A 100% first year tax allowance is currently available for companies investing in selected energy efficient technologies. Extending these to the average householder would cut the payback times cited in Table 2 to 29 years for solar PV and 11 years for micro-CHP. These periods are still too long to make investment attractive for many households.

Such a change in the fiscal rules would bring micro-CHP technologies closer to financial viability for consumers, and would help PV technology enter the timeframe of most mortgages. This has been recognised by some U.S. states, which now have tax concessions for PV investment. Meanwhile, the UK Treasury has shown a willingness to consider such changes, though there is no sign that they will be implemented in the near future. A wider implication of changes in tax incentives is that they would not just benefit micro-generation. They might also make it easier for householders to invest in many other energy saving measures, many of which have shorter paybacks and reduce carbon emissions more cheaply. Examples include more efficient central heating boilers, loft insulation and 'A' rated fridges and washing machines.

Changes in taxation alone are, however, unlikely to be sufficient to remove the barriers to demand side energy investments such as micro-generation. As the analysis of the UK situation has shown, many technical, economic and regulatory issues are being reconsidered to allow micro-generation to contribute to energy policy goals. To allow the full economic and environmental value of micro-generation to be realised, there is a need for radical reform in areas such as distribution network regulation and technical standards. Looking further ahead, the development and installation of new IT and control systems would also help. Such systems could allow micro-generation and other demand side technologies to be fully integrated within energy systems.

At the moment, the highly integrated and IT-intensive energy systems envisaged by some commentators seem to be a long way off in most countries. Even in countries with relatively decentralised energy systems such as Denmark and Holland, household energy generation is a new development. Micro-generation is at an early stage, and much depends on the reactions of the early adopters of technologies such as solar PV and micro-CHP. It has the potential to bring with it radical changes to the energy system, and to the roles of energy consumers and energy suppliers. However, much depends on the willingness of consumers to take a leap of faith and install that power station in their basement, rooftop or back yard.