SUPPLIER STRATEGIES AND RESPONSES TO INSTITUTIONAL DRIVERS FOR AN EMERGING ENERGY TECHNOLOGY

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Abstract

This paper investigates the role of suppliers of a new energy technology, when the market for that technology continues to be in a state of flux, and is characterized by continued regulatory and institutional developments. This paper first summarizes the institutional drivers resulting in the widely divergent diffusion of distributed generation (DG) based on natural gas engines in the Netherlands and the UK. Then, supplier responses to this institutionally driven market are discussed. Under regulatory support, supply firms were able to implement innovative operational and ownership arrangements, hugely growing the market while positioning themselves for new R&D and market developments. Under regulatory restrictions, supply firms fought to survive, with resultant implications for the reputation and longer term prospects for this new energy technology. The paper concludes by discussing how continuing institutional instability can limit supplier strategies based on spillovers from successful regulatory experiments. Thus the establishment of a viable energy supply industry is delayed under continuing regulatory uncertainty.

1. Introduction

This paper investigates the role of suppliers of a new energy technology, when the market for that technology continues to be in a state of flux, and is characterized by continued regulatory and institutional developments. Unlike many economic sectors, the energy industry is characterized by entrenched participants within an accepted paradigm of supply (Grubler et al, 1999). Any attempt to introduce a new technology which challenges this paradigm, will require evolving strategies by the various market participants to deal with regulatory opportunities and barriers.

Consideration of supplier strategies is important for two reasons. The first is that widespread diffusion of new energy technologies is necessary for realization of their economic and environmental benefits (Azar and Dowlatabadi, 1999). The second is that there has long been a debate about when public support for welfare enhancing energy technologies should be removed. Grubb (1997) contends that governments should aim to guide innovation and diffusion of early energy technologies in order to have the tools in hand to address environmental issues, rather than rely on 'trickle down' effects from R&D.

Section 2 provides background into the early market evolution of a new energy technology. This focuses on what is meant by "early" market development and what the expectations are for supplier strategies during this period. This paper utilizes the case study of gas engine distributed generation (DG) which saw widely divergent early market diffusion in the Netherlands and the UK. These market developments were driven by institutional differences, specifically in the interactions between utilities and adopters of this technology. This is discussed in detail in Strachan and Dowlatabadi (2002), and summarized in Section 3. Section 4 synthesizes how expert and innovative DG suppliers responded to institutional support in the Netherlands and to institutional barriers in the UK. Particular attention is given to the success of spillovers from positive regulatory experiments given market instability. Section 5 concludes by discussing the longer-term establishment of a viable energy supply industry under continuing regulatory uncertainty.

It is important to begin by defining the different roles of major market players in the early diffusion of an energy technology. A key distinction is between the institutional players who set the regulatory and economic rationale for adoption, and the market participants who respond and adapt to this market in flux. There are also more peripheral market participants, including consultants who advise on new projects, professional associations who facilitate knowledge sharing between potential adopters, energy service providers who provide outsourcing of energy requirements, and equipment vendors who provide components to the overall technology package.

- Institutional players:
    - Government – sets the overall parameters and targets for cost and environmental performance of the electricity and natural gas sectors; provides funding for pre and post commercial energy technologies; sets the evolving regulatory structure that a new energy technology must operate in.
    - Utilities – the key implementers of regulatory developments; have considerable latitude in interpreting regulations for access to the networks and appropriate fees

for interacting with that network; provides a central input into the regulatory process.
    - Technology trade-body – co-ordinates information programs and efforts to reduce the transaction costs for the new technology; provides input into the regulatory process.
- Market participants:
    - Suppliers – Generally young and under-capitalized firms serving as technology retailers, maintenance providers, and financiers of the new energy technology.
    - Adopters – Users or investors in the new technology; frequently face information barriers, and capital funding constraints when considering use of new energy equipment.

2. Background to the Early Market Evolution of a New Energy Technology

2.1. Early Supply of a New Energy Technology

Before delving into the details of this study, it is important to discuss what it meant by early supply of a new energy technology. An extensive literature on the diffusion of technologies (e.g. Bass, 1969; Rogers, 1995) has given a useful descriptive framework based on the logistic diffusion curve and its variants. Following first commercial use, early adoption occurs in niche markets, followed by a rapid rise in use as the technology is exploited in mainstream applications until finally the market becomes saturated. In this framework, *ex-post* characterization of diffusion stages can be made by examining the final levels of diffusion through time.

This framework aids the discussion over how long public support should be provided to new energy technologies. The rationale for more public R&D funding has been generally accepted (Margolis and Kammen, 1999). However, the debate continues over the appropriate role of public support for spurring such new technologies to their full market potential. Post first commercial adoption of new energy technologies, policy attention when moving from early to mainstream markets, has generally focused on adopter related market barriers (Jaffe and Stavins, 1994), including institutional 'road-blocks' such as regulatory restrictions or lack of access to existing infrastructures.

The possibilities of institutional developments restricting long term technology development ties in well to the useful concept of the "valley of death" for a new energy technology (Norberg-Bohm, 2000). This describes the inability of technologies to reach mainstream applications and hence benefit from the powerful mechanisms of economies of scale, learning curves and adopter acceptance. If enabled, these mechanisms translate into a virtuous cycle where costs and performance improvements translates into continuing adoption, and produce the rapid upswing in the S-shaped logistic diffusion curve, leading to a greater market penetration.

Thus this literature suggests that an early stage of market development can be defined where the survival and future of the new technology is in great uncertainty.

2.2. Expected Suppliers Strategies

Within early market development, the assumption of proficient and innovative suppliers has generally been assumed in energy technology commercialization studies (Norberg-Bohm, 1999). Norberg-Bohm emphasizes the importance of the size of the niche market, the technical and financial capabilities of suppliers, and stable investment conditions as key for successful diffusion. Furthermore, she argues for continuation of both supply and adopter focused public support programs until a new energy technology is firmly established. Other observers emphasize the role of institutional actors, especially utilities (Zarnikau and Reilley, 1996) and promotional organizations (van der Does et al, 1996).

However, insights from the market evolution literature suggest a far more complex range of motivations and actions by new supply firms. Sleeper (1998) discusses how firms have individual characteristics that should be considered in the diffusion process. Firm differences have been attributed to prior experience and available knowledge (Nelson, 1991), but Hannan and Freeman (1977) argue that external influences, including regulatory and institutional differences, are also important. And Holbrook et al (2000), emphasizes the importance of these individual firms in determining overall industry performance.

Klepper (1996), summarizes the expected evolution of the supply of a new technology in a competitive market. He defines product life cycle as technical, marketing and production stages. Early suppliers are at first technically innovative. Through time their innovative efforts turn to financial and managerial innovation. A shakeout of firms is expected as firms incapable of managerial and financial innovation fail to capitalize on their technical innovations. Early market leaders are expected to grow in size, reduce production costs and dominate the market. However as Powell (1991) notes, institutions are especially important in markets that are not truly competitive, and institutional or regulatory developments can drive market evolution (Scott, 1991).

Such institutional developments are crucial for the market penetration of a paradigm busting energy technology, because regulatory changes shape both the pace of diffusion and the size of the overall market potential. Specifically as seen with distributed generation (DG) technologies, any forecast based on combined heat and power demands of available sites, or on applications within the power network (peak shaving, standby supply, remote users etc), does not take into account innovative operational strategies such as clusters of DG units meeting a range of neighboring site demands via micro-grids, or deployment within power grids to replace or avoid distribution upgrades. The ability to use DG in these applications is heavily dependent on institutional developments (see Section 3). Thus early (or niche) supply is not one well-defined period, but a series of developments within a market in flux.

Therefore, in comparison to studies of diffusion, this supplier evolution literature suggest that for a new energy technology, an early market stage characterized by uncertainty, is much harder to define and periods of institutional change are likely to persist. In addition, this literature emphasizes the importance of supplier strategies for the pace and overall level of market penetration of the new energy technology.

3. Institutional Drivers of Gas Engine DG in the Netherlands and UK

This section gives a brief summary of the institutional drivers of gas engine DG diffusion in the Netherlands and UK from 1985 through 1998. A full description of this comparative analysis, the rationale for rejecting other explanations of the observed patterns of diffusion and wider consequences of institutional drivers for a new energy technology is given in Strachan and Dowlatabadi (2002). Section 4 will focus on the resultant strategies of early suppliers.

Gas engine DG is typically operated as combined heat and power (CHP), with units ranging in electrical output from 50kWe to 1,000kWe. Units are typically sized for site base-load electricity and heat requirements resulting in overall efficiencies of up to 90%. Electricity export to the distribution grid allows potential applications with variable energy requirements to be considered, with larger unit sizing if a sufficient heat base-load exists. Typical DG applications are commercial buildings or small industrial sites, and include hospitals, leisure facilities and greenhouses.

Gas engine DG has been a remarkable success in the Netherlands with over 5,000 installations and 1,500MWe of installed capacity by 1997. However, the technology has struggled in the UK with an installed capacity of only 160MWe from around 1,000 sites. The Netherlands market is only 25% of the UK, but it had 5 times as many installations than the UK. What is even more striking is that the Netherlands realized 10 times as much installed capacity as the UK (40 times on a per capita basis), implying a much larger average size of DG plant.

In both countries, ensuring a market for gas engine DG was a public policy priority for its potential to lower national CO_2 emissions, as well as reduce energy bills with this efficient CHP technology. Similarities between the two markets allow a number of commonly proposed barriers to diffusion of this new energy technology to be ruled out. Adopters were made aware of the technology, capital was available for financing investments, and from a regulatory standpoint there was open access to the electricity network.

Technical characteristics hold the key to understanding the economic deployment of this DG technology. Gas engines exhibit site economies of scale owing largely to scale invariant maintenance costs. A major maintenance cost component is man-hours for the regular monitoring and repair costs which differ little between a 50kWe unit or a 500kWe unit. Maintenance costs are thus proportionally larger (per kWe) for smaller sized units. For a positive net present value on investment, units in the UK need to be larger than around 140kWe. For the Netherlands, this size threshold drops to around 100kWe. Investments in the Netherlands have a smaller size threshold due to reduced capital and maintenance charges, and lower connection fees to the electricity network. Further, in the Netherlands, subsidies on capital purchase and fuel for gas engine DG further lowered the size threshold down to 70kWe to be profitable and improved the returns on all units.

However as shown in Figure 1, the majority of DG investments in the Netherlands were in much larger units. The UK (with a higher size threshold) had relatively many more small units. And even if average DG unit sizes were larger in the Netherlands, significant numbers of DG units would still be expected at the lowest sizes. That is, the full range of economic schemes would be expected to be exploited. However only 7% of Netherlands schemes were from 50kWe to 100kWe. This evidence contradicts the centrality of subsidies as the prime motivation for DG investments.

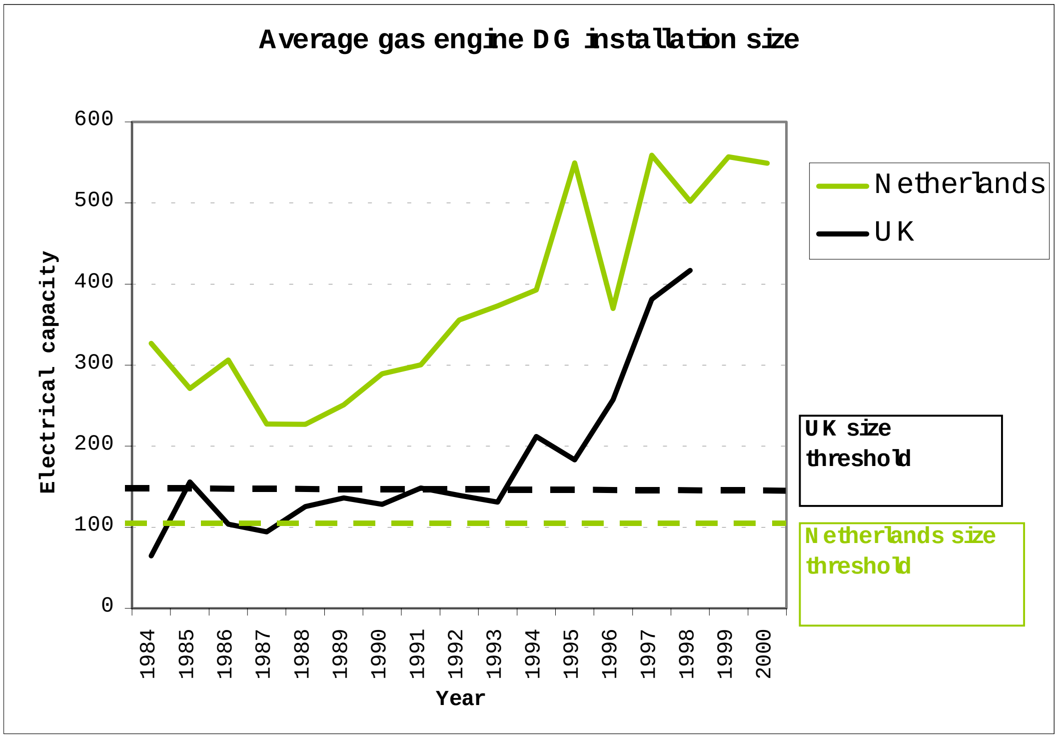

Figure 1: Average size of Netherlands and UK DG units by year

The principal difference between the two countries was that distribution utilities in the Netherlands implemented regulations and entered into joint ventures with adopters to utilize DG and promote its diffusion. A key example of this was higher electricity buy-back tariffs in the Netherlands. Electricity buy-back allows larger unit sizing and promotes use of DG on sites with limited electricity base-load demand. Low buy-back tariffs in the UK made electricity export much less attractive. Therefore in the UK, DG installations were confined to smaller, less profitable units on the reduced sub-set of sites with sufficient base-load demand for electricity.

For distribution utilities, DG provided low cost electricity and gave offered a means of access to liberalizing generation markets. DG also offers the potential for improved network management. At a minimum this requires knowledge of projected electricity production, and is greatly enhanced by distribution utilities having some control over electricity exports. As Netherlands distribution utilities were partners in DG schemes, prior knowledge and control of electricity exports could be arranged through standard contracts co-ordinated by the DG trade body. As well as meeting on-site demands (and offsetting incremental demand on the distribution network), 23% of DG electricity was exported and thus available for improved management of the distribution network.

The win-win partnership for DG between adopters and distribution utilities in the Netherlands allowed the development of an installed base of DG units. This enhanced DG uptake through economies of geographic concentration in maintenance costs. A higher density of units allows economies of geographic concentration in maintenance costs. Increasing numbers of DG units creates a virtuous circle of lower maintenance costs, improved economic return and increased sales. If such a virtuous cycle is maintained, this contributes to the rapid expansion of DG to become a mainstream energy technology.

4. Suppliers Strategies in a Market in Flux

4.1. Supplier Responses Under Institutional Support – Netherlands

DG suppliers were an integral part of the collaboration between government, utilities, adopters and the DG trade body to overcome diffusion barriers and utilize DG for national CO_2 reductions, on-site cost savings and improved management of the electricity distribution system. Suppliers delivered both technical innovations through remote operation and maintenance of units, and financial innovations through energy servicing contracts and third party financing.

Through 1997 utilities were partners in a majority of DG schemes. From 1997 onwards, the share of direct partnerships in DG ventures by utilities declined, due partly to the increasing focus by utilities on the upcoming liberalization of the Netherlands electricity sector. Also in 1996/7, a new government withdrew the capital and fuel subsidies for DG units. However as Figure 2 illustrates, new DG unit sales to private investors (although retaining favorable access to the distribution network), remained strong in the Netherlands at around 350 per annum. In terms of awareness, and proven technical and cost performance, gas engine DG supply was now safely across "the valley of death" and the industry had become firmly established.

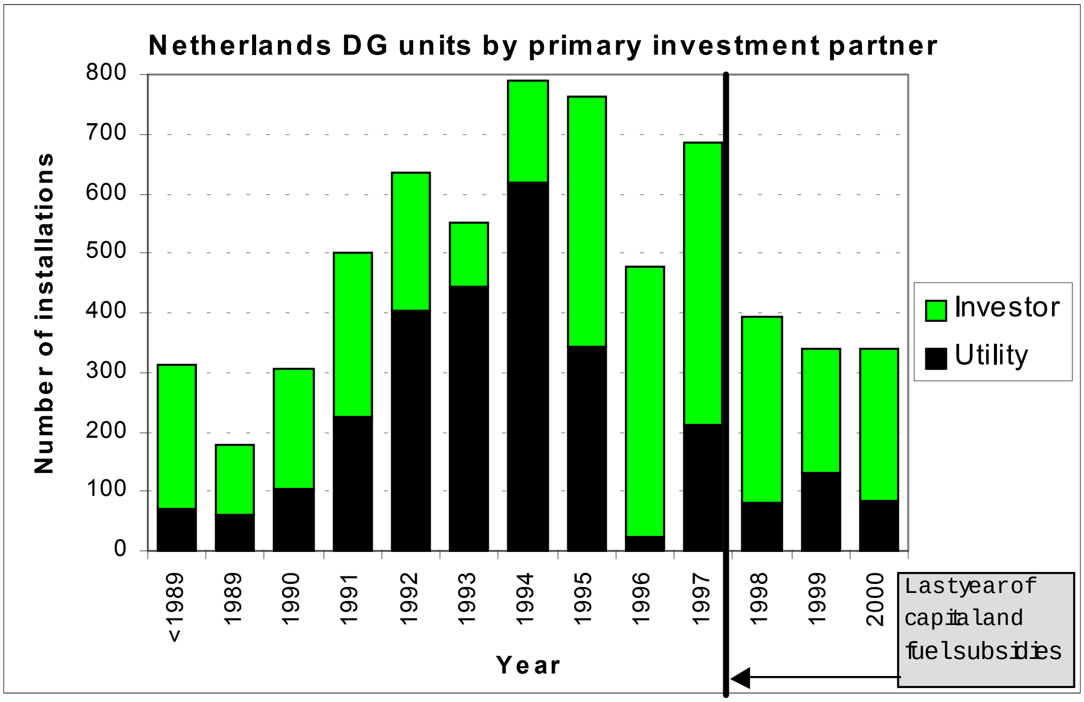

Figure 2: Netherlands DG ventures by primary investment partner

In the Netherlands, experienced and disciplined DG suppliers continued to provide innovative strategies. They diversified into other geographical markets, particularly the UK (see section 4.2), Germany and Spain. They also diversified into complementary markets including marine engines, standby power, and complete horticultural facilities based around a DG unit. As the DG market continues to develop, supply firms are working with distribution utilities to set up 'clusters' of DG units to benefit from economies of geographic concentration, and to provide utilities with significant amounts of known electricity export for network management. Pushing the envelope of electricity generation and supply options, allows consideration of micro-grids to service small areas with particular supply requirements (e.g. high standards of power quality and reliability in technology business parks). Last, with the expectation of continued regulatory developments, in this instance on local air pollution requirements, DG suppliers have entered collaborative partnerships with large energy or engineering firms with the size and resources to develop alternate DG technologies, notably micro-turbines, Stirling engines and fuel cells.

4.2. Supplier Responses Under Institutional Barriers – UK

Suppliers operating in the UK market faced a very different institutional environment. Suppliers exhibited similar initial innovations, offering remotely monitored units, packaged for simple installation. In addition, supplier financing was provided to overcome adopter concerns over initial capital investment. The industry saw an early shakeout with 15 firms coalescing into 4 main suppliers in only 5 years. Only one of these (Firm B), was a subsidiary of a successful Netherlands DG supplier.

As discussed in Section 3, UK suppliers were discouraged, due to low electricity buy-back tariffs, from exporting electricity to the grid and were thus constrained to smaller, less profitable DG units meeting only on-site electricity and heat requirements. As well as utility disinterest, electricity liberalization resulted in falling grid electricity prices and hence an extremely tough market for DG. Suppliers responded with an innovative marketing strategy to ensure firm survival, but one that was also detrimental to the long-term potential of this new energy technology.

As Figure 1 showed, through 1993 DG suppliers in the UK sold units that averaged below the calculated size threshold for an economic return on this energy efficiency investment. Given that many of these units were financed by the suppliers themselves, why were DG units with such uncertain economic returns installed? The answer lies in maintenance contracts providing secure income streams for suppliers. Suppliers partnering in a DG venture can gain income from the sale of the unit and from electricity sold to the local utility; these are both dependent on size. However, when entering a DG partnership, adopters sign a maintenance contract, usually for 10 years, which provides a fixed, size independent income stream. Thus a marketing strategy of selling as many small units as possible, and relying on revenues from maintenance operations, could ensure firm survival.

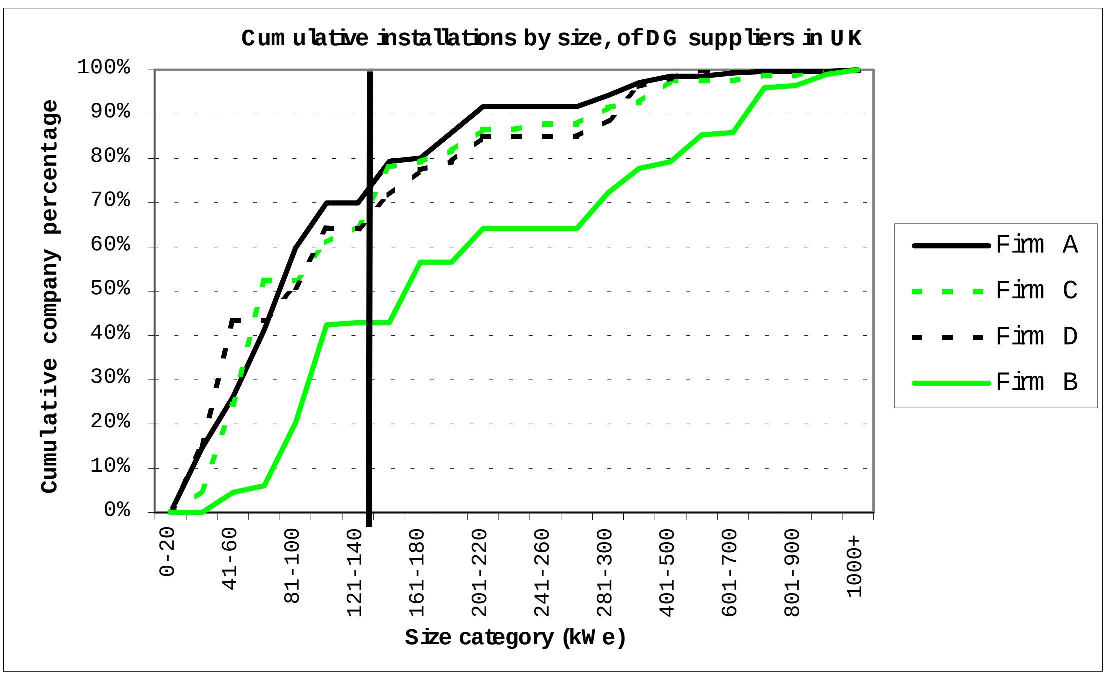

Figure 3: Cumulative UK DG units by supplier and size

This pattern of marketing to less informed adopters was not consistent across all UK supplier of gas engine DG. Figure 3 shows that the Netherlands subsidiary firm (Firm B), only installed 40% of units below this size threshold, while homegrown UK firms (Firms A, C and D) installed over 70% of all their units below the size threshold. Looking in more detail by end-use sector, shows further differences in sizing and marketing strategies. Table 1 gives a direct comparison between the installations of Firm A and Firm B. The table shows that Firm B installed on average much larger units (167kWe) than Firm A (95kWe). Firm B also marketed the DG technology in industrial applications, including placing modular DG capacity upgrades in different locations in very large industrial facilities, rather than simply rely on the conventional applications of hotels, leisure centers and hospitals. In addition, the sector that Firm B installed its smallest units in (multi-residential) was the recipient of a grants program under the auspices of the UK's Energy Saving Trust, where capital was provided to support schemes where the economics were marginal (simple payback period greater than 4 years).

	Firm A		Firm B	
	% of sites	median size (kWe)	% of sites	median size (kWe)
Hotel	36%	95	39%	110
Leisure Center	29%	95	12%	154
Hospital	23%	75	11%	383
Other Buildings	4%	148	8%	293
Multi residential	3%	95	6%	100
Sewage	2%	38	4%	128
Industry	1%	54	18%	800
Education	1%	165	2%	167
TOTAL	100%	95	100%	167

Table 1: Breakdown of DG units installed by UK supply firms A and B

The marketing strategy of selling small DG units with uncertain economic returns gives rise to concerns over the long term reputation of this new energy technology and the development of a negative adopter network where unsatisfactory experiences by early adopters limits the overall market penetration of the new technology. Moreover, as Figure 4 illustrates, after rapid sales through 1994, Firms A, B and C simply stopped new sales, instead relying on income streams from their large installed base of units. The residual capacity growth of Firms A, C and D could be viewed ex-post as a diffusion curve, but for the fact that Firm B continued to make sales following a different supply strategy, and the similar Netherlands market experienced 40 times as much capacity on a per capita basis.

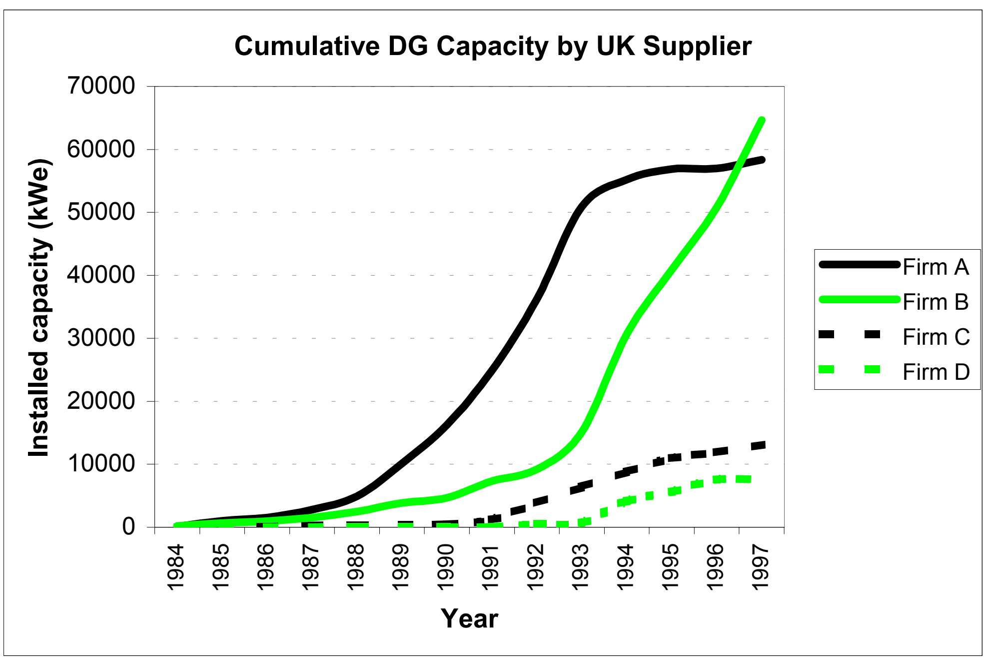

Figure 4: Cumulative DG capacity by UK supplier

Thus the successful market domination of Firm B due to the successful spillover from the institutionally supportive Netherlands market, prevented a market stagnation of the UK DG market. Firm B has been joined by a number of other Netherlands subsidiary DG suppliers to reinvigorate the UK market with win-win collaborations with utilities to meet on-site and network requirements for capacity increments.

4.3. Continuing Supplier Strategies in a Market in Flux – UK

Section 4.2 concluded with the positive message that survival focused strategies by UK suppliers in response to institutional barriers, that threatened the long term future of this new energy technology, could be overcome due to Netherland's suppliers applying lessons from DG deployment in their home market and winning market share in the UK. Unfortunately the continuation of regulatory and market instability in the UK thwarted this positive regulatory spillover.

Although a number of factors, notably fuel prices, have negatively impacted DG in the UK post 1997, a contributing element in the slow growth of DG capacity has been continuing institutional instability. Of particular importance has been how institutional changes have impacted the economics of electricity export to the grid, thus making larger DG unit sizing for economies of scale, and clustering of DG units for economies of geographic concentration, more difficult to implement.

In April 1999, the UK Climate Change Levy was announced, to begin on April 2001. The levy rate was 0.15 p/kWh for gas and coal, and 0.43 p/kWh for electricity. Although DG suppliers expected the impacts of the levy of natural gas prices, and on-site DG electricity use was exempt, the levy was imposed on DG electricity exported to the grid, making on-site only DG more attractive.

Of even greater impact was the New Electricity Trading Arrangements (NETA), introduced in March 2001. NETA was introduced by the energy regulator OFGEM (itself a recent merger between the electricity [OFFER] and natural gas [OFGAS] regulators), to replace the existing Electricity Pool mechanism for trading electricity and ensuring a balanced electricity supply. NETA replaced this pool mechanism with bilateral contracts between generators and suppliers, together with a mechanism for balancing supply and demand, as well as a futures market. NETA has generated considerable debate, including the view that smaller generators would be negatively affected due to having to rely on traders or 'consolidators' to sell their output (Ruff, 2000).

Under NETA, electricity exports from DG units could be sold to neighboring sites or locally to the distribution utility. Alternatively, DG suppliers could register as a generator and sign up to NETA's Balancing Systems Code, although none did so, presumably relecting the relatively greater effort of participation for smaller generators. The last option was to enter the futures market via an aggregating trader or consolidator. This was hoped to provide more certainty in prices for DG schemes without having to directly participate in NETA.

Early analyses of NETA showed substantial negative impacts on electricity exports from DG (OFGEM, 2001). Figure 5 shows gas engine DG units operated as CHP saw electricity exports fall by 61% with the price for electricity exports fall by 13%. For DG schemes in partnership with utilities, these were used more, but the price paid for electricity exported fell by over 50%. Similar negative impacts were also experienced by wind and other small renewable generators.

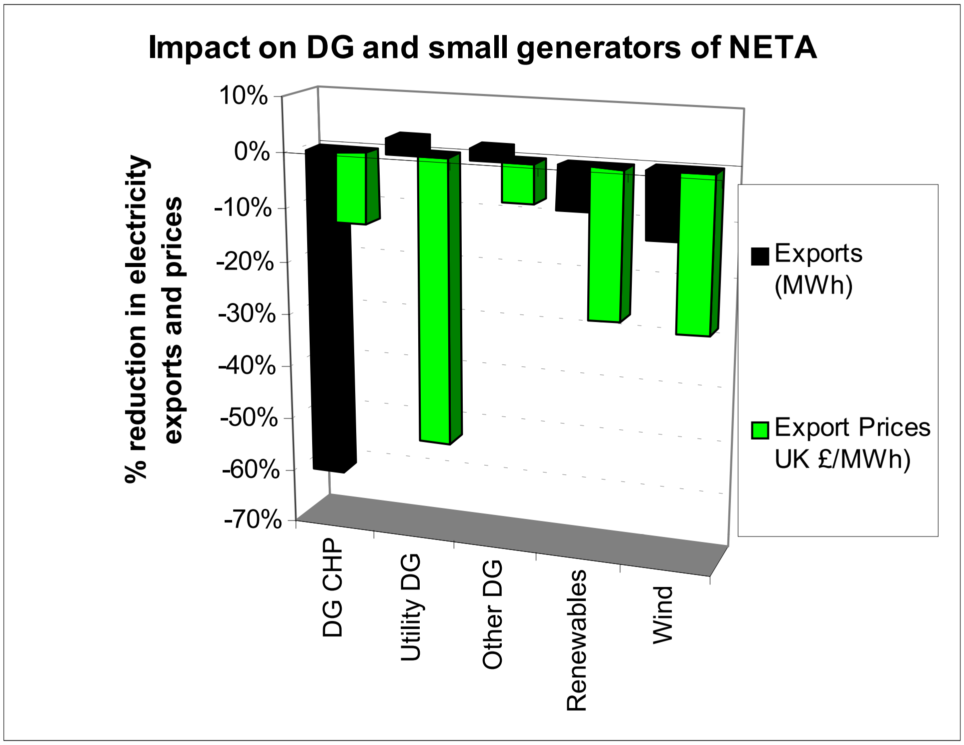

Figure 5: Impact of NETA on UK DG electricity exports

The key difficulty DG operators experienced was in their lack of market access or market power. Few consolidators initially emerged to allow DG to access the futures market, and thus bilateral agreements for DG to sell power under longer-term stable prices have been severely restricted. For those DG units in partnership with distribution utilities, the utility has been able to use its sole purchaser position to dramatically reduce the price it pays for DG electricity.

Hence, as a result of the continuing institutional instability surrounding electricity exports under NETA, DG in the UK has struggled to successfully adopt the collaborative model of DG deployment as in the successful Netherlands regulatory experiment. In response to the difficulties experienced by the DG industry, the UK government eliminated the Climate Change Levy on DG electricity exports, and reduced value added taxation on investments in DG. However, it appears that DG in the UK continues to be in the "early" stage of uncertain market development and diffusion.

5. Discussion

A number of qualitative insights can be taken from the role of early suppliers of gas engine DG, in markets characterized by institutional drivers.

First, contrary to a straightforward reading of the diffusion literature, an early market stage is very hard to define as continuing regulatory uncertainty drives the market and allows or inhibits suppliers from transiting to an established mainstream energy technology. Thus there is a continuing need for policy to shape the institutional landscape well past first commercialization.

Second, suppliers were innovative, a market shakeout did occur, and successful suppliers took advantage of regulatory opportunities to offer innovative operational strategies. This can hugely contribute to market growth for the new energy technology. However the flip side of the coin is that innovative suppliers in a market characterized by institutional barriers will pursue strategies that will guarantee their own survival. In the case of gas engine DG, this involved relying on maintenance contracts while marketing units of questionable economic return for adopters. Without spillovers from other regulatory experiments, such supplier behavior can imperil the reputation of a new energy technology, and adversely limit its overall penetration.

Third, suppliers will try to transfer successful regulatory experiments, in this case the win-win partnership with utilities to allow DG to flexibly meet on-site energy demands as well as contribute to meeting incremental load growth in distribution constrained areas. However, in this case, continued institutional instability and the continuing difficulties in exporting power at an advantageous price thwarted the application of this new paradigm of DG energy supply.

In conclusion, policies in the extended early market period of a new energy technology, should consider the impact of innovative supplier actions and how they respond to institutional opportunities and barriers.

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