SSTC-DWTC

Global Change and Sustainable development

INVENTORY AND APPROACH TO BARRIERS FOR THE CLIMATE POLICY

Project summary

Heidi Verheyen, Willem Heirman, Wim De Vos, Bruno Cassiersiteit , Johan Couder

Universiteit Antwerpen, STEM, Kleine Kauwenberg 12, 2000 Antwerpen

The promoter of this project, professor Aviel Verbruggen, participated in 'Working Group III of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)'. Working Group III treats 'The Mitigation of Climate Change'. To support this contribution to IPCC we focused our research on the barriers, opportunities and market-potential of technologies and methods. In particular we investigated two specific barriers: the pricing barriers and the cogeneration barriers.

Activities

The research revolved around two main topics :

Pricing barriers and barriers that limit the development of cogeneration, as barriers to energy-saving technologies and methods

The work was split up in 3 phases :

- The first phase involved an extensive literature study. The goal of this phase was to gain a profound insight in the new developments in the pricing and cogeneration domain;
- In the following phase, we analysed the pricing and cogeneration barriers and formulated solutions to remove the barriers;
- In the third and final phase, we made a contribution to Working Group III of the Third Assessment Report of the Intergovernmental Panel on Climate Change. The promoter of the project, prof. Aviel Verbruggen, participates in 'Working Group III of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)'. Working Group III treats 'The Mitigation of Climate Change'.

Cost efficiency of privately and publicly owned electricity systems

We tried to analyse the productive efficiency (cost efficiency) of electricity distribution systems in Flanders. In particular, we tested the null hypothesis that privately owned and publicly owned electricity systems do not have significantly different costs.

In order to do this, we used a relatively new method, called Data Envelopment Analysis (DEA). The DEA technique involves a non-stochastic approach to the measurement of productive efficiency, which allows the disaggregation of that measure into several mutually exclusive and exhaustive components. The technique is essentially comparative, in that the overall efficiency measure compares the average cost of an electricity distribution system to the average cost of least cost electricity distribution systems.

Results

Prices as barriers and opportunities for mitigation policies

“The price of a good or service is what it costs the buyer to acquire it from the seller; the same price is what the seller rewards for giving up its property rights on the good or service”. The Webster’s definition of ‘price’ is clear. However, in economic theory and practice, pricing is a complex issue with several unanswered questions. Delimiting what on pricing is covered in this report is necessary.

The Roles of Prices in Society

Economic theory proofs that in a simple society of optimising consumers and producers interacting through markets, clearing prices maximise overall welfare. Notwithstanding the many criticisms and the non-plausibility of several assumptions, the theory’s golden rule that prices should be set equal to the marginal cost of supply remains the beacon of most policies addressing pricing in e.g. regulated markets or controlling monopolistic behaviour of corporations.

Market transactions continuously reallocate the wealth of the world and allocate the growth in wealth. Prices therefore are important distributors.

Prices are ubiquitous. Particular categories of goods or services are endowed with a specific price-name, e.g. wage as the price of labour, interest rate as the price of capital, discount rate as the price of time, risk premium as the price of uncertainty, etc. Some argue that everything has its price, if not explicit than implicit, because in our societies all can be, and mostly is, traded against priced goods. This argument is the basis for assessing monetary prices for all values that are not tagged with explicit prices in some market place, e.g. natural amenities, social relationships, cultural values, and also human life.

Descriptive prices, i.e. actually observed prices, include all the effects and biases occasioned by prescriptive policy interventions. The price of oil is loaded with rents (royalties) to oil companies and to well owners. One step further, most prices in our economies are affected by the price of oil and thus by its embodied political and distributive character. In addition, many prices are directly influenced to a smaller or larger degree by policy interventions, such as taxes, subsidies, regulatory prescriptions, market structuring, etc. Attention should be focussed on where, how an to what degree prescriptive intervention should affect observed prices.

Barriers related to Pricing

The golden rule of the market price system is only golden when markets exists for all goods and services, and when these markets function properly. In practice, these conditions are not met.

1. Not all goods and services are dealt with in market places. There exist public goods that cannot be priced because enforcing property rights is impossible or extremely impractical and costly. Externalities are ubiquitous, and only a few can be internalised by suitable policy instruments;

2. Future markets and contingency markets are only partly developed;

3. When goods and services carry a price tag, the prices do not necessarily represent their true scarcity or convey the full message to consumers (see Distorted Prices).

In the real economy prices are posted by the seller, although for many products the initial posting may be only the start of a bargaining process among buyer and seller (Dorward, 1987). For many other goods and services (e.g. electricity, natural gas, oil sales to end-users) posted prices are imposed on end-users who only can decide to take or to leave the offer. The seller tries to extract the maximum out of the deal and to transfer to the own account the maximum of the benefits the buyer could get from the purchase. The seller often will obfuscate the prices e.g. by applying complex tariff schedules (electricity, gas), by bundling offers in complex trade-offs, etc. A number of marketing tools help to overcome the reluctance of the buyers before obfuscated prices and to step in the deal anyhow.

There are several reasons why real-world prices do not conform the equality to marginal costs.

1. The definitions of marginal cost is not unique. Definitions differ in the extent to which they stress the importance of short-run as opposed to long-run costs, and changes in consumption in different time periods;

2. Real markets are far from perfect;

3. Very few goods are homogeneous. Even a uniquely defined product as ‘electricity’ is heterogeneous with a different value depending on the time, the place (voltage level) and the reliability of its availability. Because a price is an amount of money for a unit of a good, prices are more unclear the more it is unclear what a unit of the good really covers. Mostly one gets an indication of the physical quantity of the good but major other attributes may remain unspecified and poorly understood.

The impact on the demand for a good by changes in its price is expressed by the (own) price elasticity. Demand also depends on prices of other goods (cross price elasticity) and on several other variables, such as household composition and income (wealth) levels. The form of a demand curve itself may be less relevant than the shifting of the curves due to variables other than the own price.

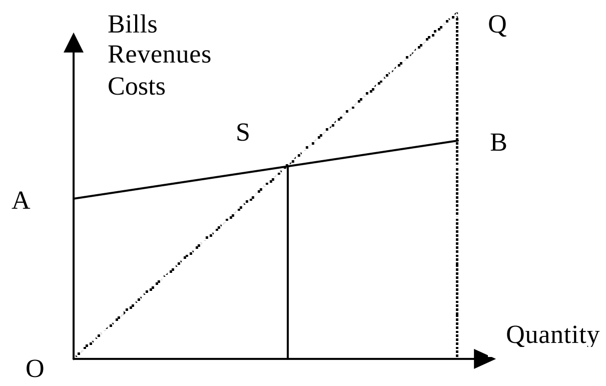
Bills convey clear messages but their impact depends on their share in the overall budget of the decision-maker being it a household, company or institution. Low prices and limited bills for carbon goods and related technologies (e.g. energy consuming equipment such as lighting appliances, air conditioners, automobiles), have resulted in high energy intensities of most human activities in industrialised nations. This situation is not favourable to the development of renewable energy resources that are characterised by low densities and intermittent supplies.

Rebound effects can diminish the effectiveness of higher energy prices (taxes). Thanks to efforts in energy conservation, the expenses for meeting particular energy services can come down significantly and economic agents save resources that can be allocated to other preferences. E.g. by installing high-efficient heating equipment in its property, the owner-occupier may reduce his personal effort in saving energy (closing doors and windows, limiting the heating of rooms that are not occupied). The sloppy behaviour is the result of low bills, because they do not warrant the time and effort to further lower the bills. In addition, energy conservation increases the budget that can be spent on other goods and services (the 'income effect'), e.g. on particular (energy-consuming) appliances or on (airborne) trips.

Non-linear price schedules, in particular two-part and block tariffs, are popular in energy pricing (figure 1). They are argued to best reflect the cost structure of the energy supplier (with a high share of fixed costs), and to be efficient in making customers pay for these costs. However, the consumer receives little incentive to conserve energy, cause success in reducing consumption is not rewarded by a proportional decline of the bill.

Other examples of split incentives are present in contracts paying fees to architects and technical advisors that are measured as a percentage of total project investment giving rise to over-sizing and to gold-plating without sufficient attention to the (energy) performance of the investments.

Figure 1: linear and non-linear tariffs



Price fluctuations cause economic optima to be ephemeral. Because most decisions involve commitments over longer-term periods, continuous adaptation to the latest energy price fluctuation is unpractical and unfeasible. This creates technical and allocative inefficiencies. The long-run evolution of energy prices is rather erratic.

CHP-barriers

Introduction

Combined heat and power (CHP) generation or co-generation is a substitute for the separate supply of heat (mostly from fossil fuels) and electricity (mostly from the interconnected grid fed by nuclear or fossil fired thermal stations, hydro or other large-scale renewable energy sources). Co-generation projects can conserve significant quantities of fossil fuels occasionally depending on the design, technology and performance of the project and depending on the efficiency and fuel type of the separate production alternatives.

Informal barriers

Efficiencies and reliability have gone up, and investment and operation costs have come down, but this information is not spread widely enough. Also on new developments (e.g. fuel cells, micro gas-turbines) little documentation is spread. Optimisation of co-generation projects requires extensive information about many determinants of profitability. Heat and power end-uses of the application and in particular the simultaneity of the load patterns, costs and tariffs of grid electricity and the terms of exchange of power with the grid, and the evolution of the fuel / energy markets should all be studied. Several key variables may change during the life-time of the plant and make investment risky. Examples of uncertain variables are fuel prices, fuel availability, regulatory conditions, environmental legislation, terms of trade with the power grid.

Barriers related to the decentralised/distributed character of the technology

Investment money for co-generation projects is more difficult to get and carries higher interest rates than funds for grid power supply extension and funds for conventional heat supply systems. Because distributed generation has to compete in many places with central supply alternatives, the much looser profitability criteria applied on the latter result in a under-development of distributed sources.

Because distributed generation has to compete in many places with central supply alternatives, the much looser profitability criteria applied on the latter result in a under-development of distributed sources. Natural gas is the most commonly used fuel for most new co-generation installations in the industrialised nations. Countries without a link to gas supply networks, or those with only a limited network, therefore face an immediate disadvantage.

Because co-generation technologies are in many countries developed by independent power producers they must compete with established pools of centralised generators that benefit from discounted fuel prices.

Procedures for authorising the construction and the operation of co-generation facilities can be bureaucratic, complex and time consuming because most were developed for central power production installations. In some countries the investments in power generation are subjected to a particular planning process, involving official hearings by parliamentary or regulatory commissions.

A small co-generation engine may be treated as a large-scale power producer, having the same (e.g. administrative) obligations in obeying environmental and emission rules. Also the higher conversion efficiency of co-generation may not be credited sufficiently by regulations directed to the conventional power sector. Environmental standards also may forbid explicitly or hinder implicitly the use of particular fuels or of particular technologies, overall or on the location of the distributed project. For example, co-generation in the built environment may have to obey very strict standards of flue gas emissions and of noise and vibration levels.

The terms of grid connection

In many power supply systems by now, there is not yet an independent system operator available that balances the offers from the various competitive suppliers. Mostly the system operator was (and in many countries still is) a part of a vertical integrated electricity supply company that moreover enjoys a monopoly position. When such electricity monopolies function within a regulatory environment of making profits proportional to electricity sales volumes, distributed generation will be approached as a loss of sales that should be avoided on all occasions.

Incumbent power companies sometimes impose very heavy regulations on producers or industries that file for a connection to the electric grid. On occasions the demander is requested to install a separate link to the next-by transformer station in the grid. The connection, the metering, the safety equipment, etc. all may be extra-ordinarily loaded to discourage independent producers.

There are three types of power flows that can be exchanged between an independent producer and the grid.

1. Surplus power that the distributed generator delivers to the grid.

2. Shortage power bought by the distributed generator at the grid: make-up (additional, complementary).

3. Shortage power: back-up.

The remuneration of surplus power is based on the principle of ‘avoided costs’ by the grid-system. In practice, one should measure the instantaneous marginal cost of the integrated power supply system taking into account generation plants’ constraints, grid constraints and reliability aspects.

Regulated ‘avoided costs’-prices and competitive marginal cost prices will entail an impediment to the development of distributed resources, when the latter generate electricity at a higher marginal cost. This can be due to a number of factors.

1. The central power may be subsidised;

2. The central system may be run on hydro-power or on nuclear power, that are both characterised by low short-run marginal costs;

3. Central power systems may face significant over-capacities in generation plant that depress short-run marginal costs below the long-run ones;

4. The marginal cost of electricity transport over the grid may increase because of growing power trade and because of difficulties in getting licenses for new lines.

Make-up power is the power in top of the own production required by a distributed generator for meeting the own end-uses. Depending on the heat and electricity load profiles, the amount of make-up power tapped from the grid may be large or small, stable or fluctuating over time. In principle, make-up power should be billed to the distributed generator at the same tariffs conventional customers are charged. This is not always the case, because in some countries make-up power is charged at special rates based on arguments that make-up power shows more irregular load profiles than normal electricity demand.

When the own generation plant is in forced outage most distributed generators will want to tap power from the grid, especially when the end-uses serve processes of high value or urgency. In many systems back-up power supplies by the grid carry high prices. This is the result of the joint occurrence of on the one hand applying the overall customer tariff on the back-up supplies, and on the other hand the property that most of these tariffs encompass a high fixed (per kW) term.

On some occasions, distributed generators may want to wheel power over the grid to related companies or to customers that are willing to pay a higher price for the surplus power or to producers that are charging a lower price for shortage power. These transactions are impeded when transporting power over the grid is loaded with predatory tariffs.

As far as energy policy is concerned, a distinction has to be made between co-generation linked to district heating (utility co-generation) and on-site independent co-generation is necessary.

Very few nations in the world own the intellectual and administrative capacity to realise a full-scale and comprehensive integrated energy policy plan, that preserves the place for district heating and related co-generation. This option is a very capital-intensive one, but also a long-lasting and environmentally resilient one. Only when the time preference (discount rate) of energy planning authorities is low and when externalities are considered as important factors in weighing energy supply alternatives, can district heating thrive in urban settlings.

Distributed generation will develop more fully when electricity markets are opened to competition that brings more exit and entry opportunities and more choice for market participants. Competition should then develop power tariffs reflecting the short-run marginal costs of supply. It should bring forward ranges of contracting opportunities (e.g. also covering reserve power deliveries) and it should free the access to the electricity transmission grids for third parties. However, fair competition in the electricity sector must be organised by enlightened regulators. Firm public policy and regulatory authority are necessary to install and safeguard harmonised conditions for all participants, transparency of the processes and unbundling of the main power supply functions. Most countries lack the intellectual and administrative capabilities for the foundation of authoritative regulatory services. This will lead to sub-optimal returns from the liberalisation process for options such as distributed generation and co-generation.

Cost efficiency of privately and publicly owned electricity systems

Productivity is simply the ratio of a firm's output to its input. To calculate total factor productivity, multiple outputs and multiple inputs are aggregated such that output and input are each represented by scalars. Productivity will vary depending on technology and many other factors. *Productive efficiency* refers to the optimal use of resources in the production process. To achieve productive efficiency, a firm wants to reap all possible economies of scale and produce at the lowest possible per unit cost, i.e. at the minimum point of the average total cost curve.

We used a relatively new method, called Data Envelopment Analysis (DEA) to analyse the productive efficiency (cost efficiency) of privately and publicly owned electricity distribution systems.

DEA in a nutshell

DEA is commonly used to evaluate the efficiency of a number of producers. In the DEA literature, a producer is usually referred to as a decision making unit (DMU).

DEA is an extreme point method, and compares each producer with only the 'best' producers. The heart of the analysis lies in finding the 'best virtual producer' for each 'real producer'. If the virtual producer is better than the original producer by either making more output with the same input, or making the same output with less input, then the original producer is inefficient. The procedure of finding the best virtual producer can be formulated as a linear program (LP). An LP of that form must be solved for each of the DMUs.

DEA can easily handle multiple input and multiple output models, it doesn't require an assumption of a functional form relating inputs to outputs, DMUs are directly compared against a 'best performing DMU' or combination of 'best performing DMUs', and inputs and outputs can have very different units. Some of the advantages of non-parametric DEA approach over parametric approaches are the robustness of the linear programming methods used to solve the DEA problems, and the fact that a variable that is neither an economic resource nor a product, but is an attribute of the environment or of the production process, can easily be included in a DEA-based production model.

DEA also suffers from a number of limitations.

- Noise (even symmetrical noise with zero mean) such as measurement error, can cause significant problems;

- DEA is good at estimating 'relative' efficiency of a DMU, but it converges very slowly to 'absolute' efficiency. In other words, it can tell you how well a DMU is doing compared to its 'best performing DMUs, but not compared to a theoretical maximum;

- statistical hypothesis tests are difficult (DEA being a *non-parametric* approach);

- large problems can be computationally intensive.

Results

To date, there is a vast literature in microeconomics that addresses the question of why ownership matters. Empirical implications to test whether ownership indeed matters are:

- Publicly owned enterprises in competitive environments do not perform better than privately owned companies in the same circumstances in terms of profitability and efficiency, and could perform worse;

- One should expect important efficiency gains from the change in ownership structure in competitive sectors;

- Increases in profitability are not equivalent to increases in efficiency in general. This will only be true in a competitive environment;

- Fully privatized firms should perform better than firms that have been partially privatized, under the same conditions.

A paper written by M. Pollit [Pollit, 1997] discusses the effect of ownership on productive efficiency in electric utilities. According to Pollit the UK seems to be a case where privatisation had resulted in lower costs of production. This however does not mean that ownership change per se would lead to lower costs. The evidence from the US is that there was no difference in costs between private and publicly owned electric utilities. The lesson for other countries is that small municipally owned electricity distribution companies might well be just as efficient than large privately owned distribution systems

Massimo Filippini and Jörg Wild are conducting a similar study for Switzerland, namely investigating the influence of institutional form and ownership on the efficiency of the 1.000 or so utilities that make up the Swiss electricity industry. They have not produced any results so far.

Our own research for the Belgian electricity distribution systems seems to indicate that privately owned electricity distribution systems are not necessarily more cost efficient than publicly owned ones.

Conclusions and suggestions for further research

The non-parametric methodology has seen extensive application for the analysis of utilities (gas, water and electricity companies). Many of these studies are performed to assist the regulation of utilities by government institutions. Some apparent shortcomings are:

- errors-in-variables appear highly relevant, e.g. due to the freedom firms have in allocating their costs to different periods and different activities;

- the small number of firms in the sector can cause small sample error;

- local market conditions suggest that electricity prices are endogenous and uncertain in a non-trivial way, and hence traditional methodologies do not apply.

There is a clear need for developing models that account for errrors-in-variables, sampling error and endogenous and uncertain prices. A research program founded by (amongst other) Thierry Post at the Erasmus University Rotterdam has the objective to extend the current non-parametric methodologies in order to take these shortcomings into account, and to apply the new methodology for assessing the efficiency and productivity for European utilities.

Selection of references

Pollitt, M.G. (1997) *Ownership, Costs and Prices in Electric Utilities*, in: Oxford Energy Forum, Issue 30, August, pp. 9-10.

B. F. Roberts, *Performance-Based Regulation:Efficiency and the Measurement of Productivity Offset*, ESC ELECTRIC UTILITY ANALYSIS REPORT 95-1, Economic Sciences Corporation, 1995.

Massimo Filippini, Jörg Wild: *Influence of Ownership and Institutional Form on the Efficiency of Electric Utilities*, CEPE - Centre for Energy Policy and Economics, Zürich, 2001.