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TARIFF REGULATION AND COMPETITION AS MEANS TO IMPROVE THE MARKET PENETRATION OF DISTRICT HEATING AND COOLING SYSTEMS

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ABSTRACT

The environmental and economic virtues of district heating (DH) and cooling (DHC) are already known in theoretical and empirical literature: lower attention, on the contrary, has been devoted to other, socially relevant, aspects of DHC like the – not really fast – growth and in particular to those aspects related to incentives, property structure and tariff regulation.

DH tariff setting and dynamics are usually not regulated in Italy and in Europe: nevertheless DH is, with regards to the heating service, a perfect natural monopoly in the distribution segment. The absence of regulation exposes consumers to possible exploitations by a monopolist willing to maximise his profit.

Considering the strong pressure against DHC projects coming from conflicting market interest and the relevant transaction and regulatory costs, a bit of regulation of the costs and tariffs might improve the penetration capacity of the technology and should be welcomed by DHC true supporters.

The paper presents:

1. a framework agenda for a regulatory oriented analysis
2. the dataset necessary to the analysis
3. the methodological steps to be followed

Keywords: CHP, district heating and cooling, natural monopoly, position rents

INTRODUCTION

The environmental and economic virtues of district heating and cooling (DHC) are already known in theoretical and empirical literature (IEA, 2000; European Commission, 2005; G. Genon et al., 2007). In fact emphasis on the global positive emission balance, energy efficiency and private cost savings, correctly accompany all DHC project lobbying, though local emissions and externalities balance is more controversial due to the greater complexity of dealing with the effect of various energy production scenarios on air quality at regional level or at local level.

Policy and academic debate has also focused on property of assets and networks and the structure of incentives (among others H. K. Jacobsen et al, 2006). Lower attention, on the contrary, has been devoted to other, socially relevant, aspects of DHC (not very speedy) growth, in particular those relating to tariff regulation. The allocation of costs in combined heat and power (CHP) plants has in many cases resulted in the benefits of the joint production being allocated to electricity rather than attempting to share the benefits with the two products, which is typically considered to be a cross-subsidy. According to international studies (World Bank, 2003) prices for heat from the CHP plants have been likely too high in east European countries, suggesting that CHP produces a flow of rents stemming out from heat selling. The issue of the rent coming from heat selling could be raised also in western countries where heat price from DH is normally indexed to the most common alternative (e.g. natural gas, in Northern Italy).

All these aspects are crucial to understand the way DHC projects find the way to the market, the economic and environmental results and the issue of consumer protection.

A lot of barriers, of different nature, hinder the increase of the share of CHP, among others: authorization and permit requirements, lack of internalization of environmental costs in energy prices, uncertainty in tariffs and energy prices, charges for access to/and use of the grid. In particular, if environmental costs and benefits were acknowledged and included in energy prices, this would benefit the situation of CHP since the plants are environmentally more efficient than plants for separate production of electricity and heat. Alongside with environmental policy, tariff regulation could also help consumer and DH development.

NATURE OF THE SERVICE AND REGULATION

The decision about policy intervention in market mechanisms stands upon the presence of relevant market failures, mainly due to market power and externalities. In particular, the potential submission to regulation of prices of specific goods and services is a complex question that refers to the protection of consumer from market incumbents' possible abuses. Industrial economics and the theory of regulation has strongly developed since seminal papers appeared (H. Demsetz, 1968: M. Loeb, W. Magat, 1979; D. Baron, R. Myerson, 1982), bridged to mechanism desing and game theory instruments (J.J. Laffont, J. Tirole, 1993): it actually provides the framework to develop economic analysis of DH costs and tariff and policy options. The basic questions are as follows:

- in which phases is DH a natural monopoly ?
- what is the mechanism of cost building and sharing between heat and power ?
- are there relevant externalities ?
- are there distributional and social aspects to be considered ?

The monopolistic nature of the heat distribution phase (the base for price regulation) seems to be evident considering the high cost for the single client who is willing to go from DH back to traditional alternatives; in the production phase, on the contrary, competition among heat producers is in principle possible and calls for network access regulation in order to avoid discriminatory behaviour from incumbent producer that might also own the pipes. The case of thermal power coming from different sources (i.e. different plants) and using a unique network requires rules and an authority, as electricity and gas markets know very well: if, for example, a city served by DH builds a waste to energy (WTE) plant the willingness of the WTE plant to sell heat to DH network could be a problem if the power stations don't belong to the same owner. The presence of more than one source of heat in the same district removes some monopolistic ties and, in theory, lets market wind to blow in: in particular, it forces the incumbent to enter into a bargain on the market value of the heat that he is obliged to accept in his pipelines, disclosing figures and clearing the way for a virtual accounting unbundling (being the actual accounting separation - unfortunately for consumers - not mandatory).

In liberalized markets, pricing heat and power from CHP production for DH strongly depends on the nature of the liberalized electricity market, from one side, and the monopolistic heat market on the other. The hypothesis of cross-subsidiation from heat to electricity stands on the well grounded analysis of the CHP industrial cost structure. In theory, if a product is sold at a price which is less than its production cost and the loss is financed by an increase in the price of another product, which is in a dominant position, this would be considered an abuse by generally accepted antitrust rules.

A reference for the regulation of heat price is contained in the EU Electricity Directive 96/92/EC which forbids cross-subsidization: unfortunately it does not provide instructions as to how to allocate the costs of CHP to ensure that cross-subsidization does not take place between heat and electricity. As a result, there are almost as many different cost allocation methodologies used inside the EU as many different companies.

In Italy, a lot of tariffs for local and national services are submitted to strict regulation governed by special authorities: water, electricity, natural gas, municipal waste, local transport, postal service are, among other, taken out from the free market.

District Heating tariff, on the contrary, is not regulated. A single decision from the higher administrative court (*Consiglio di Stato*) seems to put DH in the domain of free market services. Yet, the specificity of the case from which the sentence stems out raises some doubts about possible generalisations: in that case, in fact, there is not a dense network but just detached large clients. Indeed some of the motivations on which the sentence is based on – e.g. the absence of buying obligations - seem to be flawed: what about the same absence in the strictly regulated system for railway tickets or fixed-line telephone services? Anyway, DH promoters in Italy are used to stand on this judgement when bargaining with the municipalities about the economic condition of the service for connected residents.

In Sweden, to quote a northern country, DH was used to be strictly regulated by Local Authority Act before the big wave of liberalization/privatization mantra (P. Westin, F. Lagergren, 2002). In the early '90 the Swedish Competition Authority has mentioned on several occasions to the Government that a price regulation ought to be reinstated, signalling cross-subsidy practices between monopolistic district heating and competitive electricity production and sales:

"*The distribution of hot water should be compared to the transmission of electricity on the grid and both services are natural monopolies*" (KKV, 2001).

"District heating prices vary significantly between different municipalities, which might be an indication that district heating companies are taking advantage of their monopoly position when pricing district heating" (KKV, 1999).

Notwithstanding the position of the Antitrust, Swedish Parliament decided in 1996 to exclude DH from the domain of regulated sector.

In Denmark, too, the government has started to pay attention to cogeneration plants as well as to their captive customers when parts of the fuel market have been opened for competition in accordance with EU-regulations.

In Slovenia setting of prices for district heating were based (in 2007) upon a prescribed methodology and generally did not reflect the real costs (Koletnik, 2007).

An update of the international regulatory framework at European level is at the moment a main issue of the research agenda at Fondazione per l'Ambiente in Torino, Italy.

RELEVANT ACTORS, INCENTIVE STRUCTURE AND GOVERNANCE

DHC projects life cycle is crowded by different actors: municipalities, local utilities, promoters, private developers, sub-contractors, energy competitors, project-financers, banks and consumer cartels.

The structure of incentives underlying the behaviour of subjects involved in DHC projects is pretty complicated: a policy-oriented forum/research should assume, for simplicity, the following incentive structure:

- municipalities are reactive to political agenda and local finance constraints;
- regulators minimize social cost of the service given the quality/quantity constraints;
- local utilities maximise profit/turn-over with the constraint of political patronage in case of public ownership;
- promoters maximise the commission/fee for project-procurement;
- private developer, sub-contractors, project-financers, banks and energy competitors maximize profits;
- consumer cartels minimize tariffs.

In a typical principal-agent scenario (J.J. Laffont, J. Tirole, 1993) the main subjects involved are the regulated firm and the regulator, with different and unconverging incentives: the theory of mechanism design allows to build up regulatory schemes that are supposed to get the socially desired goals. Mainstream theory represents the relation between regulated firm and regulators as the first maximising:

$$U= R - \Phi(\sigma) \quad (1)$$

Where U is the firm's utility, t the amount of revenues and $\Phi(\sigma)$ the disutility function of the firm's effort. Revenues depend on the regulatory contract:

$$R= A- \beta(C) \quad (2)$$

Where A is a fixed allowance and β a measure of the power of incentive scheme with values in the range 0-1.

The fight of regulators and researchers against information asymmetries shows - in sectors covered by local multiutilities - some specificity. Normally, all over European cities and counties, we can observe a political symbiosis between local political humus and utilities governance. The equity ownership by municipalities is the most common framework: politicians, civil servants, professionals, sometimes former union activists, flow from seat to seat through cooptation and patronage (F. Becchis, 2003). In a sense, local clubbing could soften the game between regulated managers and regulators, introducing trust and commitments where theory spots only opportunistic and strategic behaviour.

Anyhow, cost discovery deserves attention in order to set correct tariffs: the next paragraph will come back to the issue.

In the early phase of DH projects there are conflict of interests among producers which compete in the market for domestic heat (natural gas, other fuels, DHC). In Italy, where the prevailing technology is based on natural gas distributed through networks, DH is basically a competitor of natural gas suppliers; sometimes the two actors belong to the same utility.

Anyway, consistent profit expectation (and public allowances) could drive rent-seeking private capital but also public owners looking for local revenues from improper taxation.

When DH systems are established, the absence of regulation, alongside with the attractive discounted tariffs that may arise (some preliminary results from our survey in the north-eastern Italian area show an average of 5-10% less than the market prices with conventional fuels and standard boilers) designed for capturing clients in the launch phase, exposes consumers to future exploitations by a monopolist willing to maximise his profits. Pricing rules based on "*pegging*" to a reference good are not only a distinctive feature of DH, being common also for natural gas and commercial firewood. In general, pegging is a common practice when market is in short supply and competition is hindered by market power.

Actually DH incumbents enjoy, with respect of regulators, typical informational rents due to monitoring costs; inside the firm, yet, managers can extract informational rents at the expense of the equity owners reducing the effort to out-of-sight levels. This may end up to, for example, non-competitive acquisition of fuel and other inputs, high transmission losses or excessive operating costs.

Incentives are strictly correlated with ownership of plants and networks. The ownership structure of DH systems actually shows prevailing local public presence all over Europe: in Denmark, nevertheless, there is a strong presence of cooperative non-profit utilities (84%) (P.J. Agrell, P. Bogetoft, 2005). A key role is played also by the local authorities, directly in the authorization phase (being the utilities totally or partially owned by municipalities) and also as planners. City masterplan prescriptions influence the economies of density and per-capita return of DH systems: firms tend consequently to lobby planners to obtain urban rules that fit network claims for clients and large buildings.

Public housing associations, acting as monopsonists or oligopsonists could act as counterbalance against the strong power of the monopolistic supplier of heat: this issue should deserve more attention in the research outlook.

Fiscal and other regulatory incentives (subsidies, taxes on fuels, green tradable certificates, VAT on service) play a big role in actors' decisions causing also some conflicts. In Italy, for example, electricity from CHP powered by biodegradable waste and biomass/biogas (according to a fairly complex legislative framework of requirements) is strongly subsidized by tradable green certificates: the trade-off between electricity and heat in CHP plants in some cases charges heat production with the improper opportunity cost of lost energy efficiency certificates, distorting incentives against a technological option that should be encouraged. At the same time in Italy the fiscal abatement on VAT for domestic heat coming from biomass fuelled plants explains practically all the discount that distributors propose to clients in comparison to natural gas. District heat in the heat sector in Sweden, on the contrary, is favoured compared to other countries due to high consumption taxes on oil, natural gas and electricity. (C. Reidhav, S. Werner, 2008).

COSTS THEORY, COST ASSESSMENTS AND TARIFFS SETTING

The cost structure of DHC life-time project is actually highly variable depending on: power plants configuration and scale, fuel types, transaction and administrative costs, networks extension and density, plumbing and connection costs, maintenance policy. Due to the prevailing cogeneration asset, cost sharing is a main issue.

According to the World Bank, "*because there are typically substantial costs fixed and common to both products in a multi-product enterprise, such as a CHP plant which produces heat and electricity, and there is no way, based on the pertinent facts, to determine what share of those costs is attributable to one or the other product, the allocation of costs in a multi-product enterprise is always arbitrary*" (World Bank, 2003).

Different cost assessment method are proposed in literature: among the most used are those that allocate total costs according to the relative revenues stemming from different products (i,j):

$$CT_i = (R_i/(R_i+R_j))CT \quad (3)$$

In more operative versions only variable costs are allocated, to reflects the way utilities commonly decide about prices with mark-up on marginal costs and just ignoring fixed costs (amortization, repayments, insurance, overheads):

$$CV_i = (R_i/(R_i+R_j))CV \quad (4)$$

Another method simply establishes the cost at the level of the alternative way of the product supply in a mono-product plant: the costs of CHP heat, for example, are fixed at the same level of separate production of heat in heat only production contexts and the rest of CHP production costs are allocated to electricity.

Alongside typical economic formulas for cost allocation, energy analysts have proposed a method based on the exergy content of the products. A part from the difficulties to estimate it, exergy-based methods recall long established theoretical quarrels among economics and ecological economics on the foundations of the theory of value: while economists refer to market values corrected with externalities, some ecological economists prefer energy content/quality. However the debate falls well away from the scope of this paper.

A comparison among the consequences of applying different cost allocation methods on combined-cycle gas turbine (CCGT) systems has been provided by the World Bank and here reported in Fig. 1 and Fig. 2.

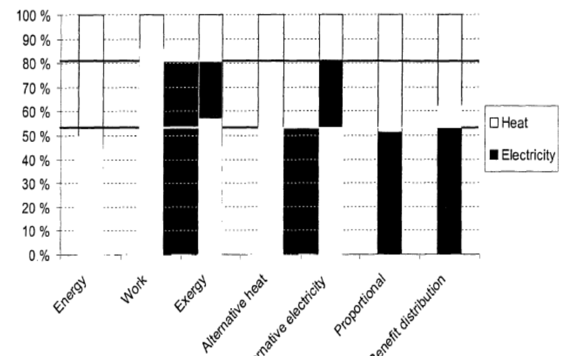

Fig. 1. Comparison of different methods for allocating variable costs, CCGT Plant [Source: World Bank, 2003].

In case of CHP in plants with steam cycles with extraction or in CCGT plants, the main variable cost of DH seems to be the trade-off between heat delivery and electricity production, other costs being fixed (amortization, maintenance, overheads). Cost allocation could, in this case, mirror the economic opportunity-cost derived from applying market values to the technical trade-off function between electrical and thermal energy production:

$$P_{MWhe} = P^*_{MWhe} - \tau Q_{MWht} \quad (5)$$

To perform a monetary balance is necessary to transform the technical isoquant in economic terms (giving a price to heat and electricity). Feed-in subsidies for electricity from renewable (but not for heat) and CHP can act as a disturbance (heat delivery, depending on the technology used, might mean proportionally less electricity and, consequently, subsidies, as in the Italian case).

As to fixed costs, contrary to the common sense and market operator claims, at a first back-of-the-envelope accounting estimate network amortization (frequently cited by local distributors as a major element) seems to fail to reach very large percentage of the yearly average family heating bill. Nevertheless, the impossibility of more than a single hot water network explains well the first condition of being a natural monopoly; amortization of connections costs should be also considered and they may completely change the results (E. Sandberg, 2004).

For example, setting at 600€/m the average cost of network construction and 30 years the life span for accounting purposes (3,33% for amortization), a network of 200.000 m serving 89.000 households (these average values come from a preliminary analysis of north-eastern Italian data) claims for only 55€ on a typical household yearly bill (straight line amortization). Also forcing basic assumption (higher amortization rates, higher unit connection costs etc) the results fall far from being the greater slice of cake in the cost analysis.

Symbol	Basic data is for modern power plants in typical operation environment		Natural gas-fired combined-cycle CHP Plant	Coal-fired CHP plant
	Electricity output, MW		120	60
	Thermal output, MW		120	120
	Efficiency		90%	88%
	Power to heat ratio		1.0	0.5
	Fuel input, MW		267	205
	Peak load hours, h/a		5,000	5,000
E	Electricity generation, GWh		600	300
H	Heat generation, GWh		600	600
F	Fuel consumption, GWh		1,333	1,023
	Fuel costs, EUR/MWh	Variable costs are typical values in Europe (Finland)	13.50	5.40
	Other variable costs, EUR/MWh		1.05	1.40
VC	Total variable cost of CHP plant, MEUR/a		19.40	6.95

Basic Data of Alternative Heat-Only-Plants

Symbol	Basic data is for modern power plants in typical operation environment		Natural gas-fired Heat-only-plant	Coal-fired Heat-only-plant
	Thermal output, MW		120	120
η_h	Efficiency of separate heat production		92%	90%
	Fuel input, MW		130	133
	Peak load hours, h/a		5,000	5,000
	Heat generation, GWh		600	600
F_h'	Fuel consumption, GWh		652	667
	Fuel costs, EUR/MWh	Variable costs are typical values in Europe (Finland)	13.50	5.40
	Other variable costs, EUR/MWh		0.36	1.44
$VC_{a,th}$	Total Variable cost of alternative heat, MEUR/a		9.04	4.56

Basic Data of Alternative Electricity Condensing Plants

Symbol	Basic data is for modern power plants in typical operation environment		Natural gas fired combined cycle condensing plant	Coal-fired Condensing plant
	Electricity output, MW		120	60
η_e	Efficiency of condensing power production		56%	39%
	Fuel input, MW		214	154
	Peak load hours, h/a		5,000	5,000
	Electricity generation, GWh		600	300
F_e'	Fuel consumption, GWh		1,071	769
	Fuel costs, EUR/MWh	Variable costs are typical values in Europe (Finland)	13.50	5.40
	Other variable costs, EUR/MWh		1.05	1.40
$VC_{a,e}$	Total variable cost of alternative electricity, MEUR/a		15.59	5.23

Fig. 2. Calculations of the comparison of different cost allocation methodologies (VC) as applied to two typical CUP plants [Source: World Bank, 2003]

Furthermore, sparse DHC areas need a particular analysis due to higher marginal connection costs (C. Reidhav, S. Werner, 2008).

DH tariffs across European cities show, at a preliminary - thus not statistically relevant - survey, high variability. Our research aims at getting a broader tariff data set and at highlighting factors explaining this variability, for example economies of scale and plant and network configurations.

LOCAL AND GLOBAL EXTERNALITIES

The cogeneration and poly-generation are generally winning strategies from the point of view of the production of greenhouse gas, in fact if compared with a production only limited to power (i.e. separate production) and under the same conditions of power and heat demand, they are more energy efficient and so less CO_2 is emitted in the atmosphere. The size of the power plant is a key issue for the overall efficiency of energy transformations and so also for the ratio between CO_2 emitted and the energy flow net usage (the difference between the primary energy and the secondary energy).

In such a context the verification appears very simple, with the logic hypothesis of a complete oxidation of fuels and a consequential stoichiometric transfer of the carbon to the flue gas: starting from the information about the composition of the fuel and its calorific value and from the information about the efficiency obtainable in different energy uses, the quantification of CO_2 emission thanks to energy and chemical balances is straightforward.

Dealing with the effect of various energy production scenarios on air quality at regional level (long-distance transport of acidifying substances, secondary aerosol formation, photochemical smog phenomena) or at local level (presence of fine particulate matter, nitrogen oxides, volatile organic compounds or other polluters associated to the flue gases), is far more complicated than the evaluation of the effects at global level. In fact when it is relevant to define the environmental balance (better or worse) coming from the substitution of a traditional energy production scenario with an innovative one (i.e. DH or DHC), characterized by a different technology layout, the following steps have to be taken into account to carry out the analysis:

- evaluation of the emission flows for each system that has been installed;
- acquisition and validation of a model that can be applied to the specific geographic context; the model must be able to build, with a correct interpretation of the physical and chemical-physical phenomena of the area, an air quality map related to a specific and fully determined emission scenario;
- usage of the predictive model in order to build an air quality map related to the innovative energy system that has to be assessed.

It is clear that the localization of emission point on the territory is also relevant and it can influence the final result, the same can be said about the sensitivity, with respect to the dispersion and transformation of emitted polluters, of the geographical areas where emitters are localized. A simplified comparison that does not take into account all these elements (it happens very often in LCA-like analyses) seems to be not correct and may bring results which can be in contrast with what may stem from an in-depth analysis of the effect on the environment.

SOCIAL IMPACT AND POLICY CORRECTIONS

Taxes and charges on fuel, notwithstanding the positive role in environmental policies, tend unfortunately to fall hardest on the poorest, directly through consumption or indirectly through “pass-through” tax favoured by sticky demand curves. Actually, the big rise in fuel price in the last months could be seen as a (virtual) carbon tax: some successes in reducing demand are in sight but distributional worries are growing.

House heating, the most price-insensitive part of domestic energy demand, amounts to a big share of private expenditures especially in northern countries: to put it simple, it frequently calls for more than an average monthly wage, not so far from the range 20% - 40% of total income reported for east Europe countries at the beginning of the 90s (World Bank 2003). In the United Kingdom, according to a study by the Institute for Fiscal Studies conducted in 2007, the poorest decile of the population spends 12% of the income on fuel (D. Fullerton, A. Leicester, S. Smith, 2007). Considering a not so unrealistic +50% factor in a carbon tax scenario, this would drive the poorest to lose six percentage points of income. Furthermore, the rich can afford energy efficiency investment precluded to the poorest, in particular those on buildings structure, like insulation, and energy systems.

Italy is, in this scenario, a paradigmatic case, with different impacts of heating expenditures on purchasing power from north to south (R. Miniaci, C. Scarpa, P. Valbonesi, 2006).

Social impact of space heating and hot water in poor or transition countries seems also to be a crucial point in the political agenda (World Bank, 2003): nevertheless our research agenda is focused on western countries tariffs and regulation.

Another distributive aspect refers to districts where DH coexists with other technologies, mainly natural gas and biomass. A possible stricter regulation of DH tariffs could broaden the gap between the bill of neighbours with very similar houses and life styles: according to some this could create some embarrass for the local government.

Academic literature suggests policy corrections to protect low income citizens in presence of green taxes on energy (J. Rowntree Foundation, 2004). The most common intervention is on tariffs or subsidies, with special discounts or allowances for poor people: nevertheless, compensation packages imply a higher marginal tax rate on the poor (since benefits disappear as income rise) and, by the way, act as counterincentives to energy frugality, due to changes in everyday behaviour, and energy efficiency through household investments.

CONCLUSIONS AND RESEARCH OUTLOOK

In this picture, notwithstanding the lack of empirical analysis, the hypothesis of DHC exploiting (unquantified) position rents deserves more than an expected reproach for the lack of respect towards an environmental hero.

Considering the strong pressure against DHC projects coming from conflicting market interests and the enormous transaction and regulatory costs, a bit of regulation of the costs and tariffs could improve the penetration capacity of the technology and should be welcomed by DHC true supporters. In 1993, as an example, a study commissioned by the UK government concluded that waste heat utilisation in the UK was low because of (among the others) reluctance of involved bodies (ETSU, 2003).

As to district cooling , a sister technology of DH, due to the nature of indoor conditioning as a non primary good and to the absence of monopoly (room air conditioners are always available as alternatives) there seems to be no theoretical ground for tariff regulation (Fondazione per l'Ambiente, 2003).

This paper outlines the framework for an empirical analysis to check the hypothesis, presents the data needs and suggests the methodological steps to be followed.

NOMENCLATURE

U firm's utility
R revenues
$\Phi(\sigma)$ disutility function of the firm's effort
A fixed allowance
β measure of the power of incentive scheme with values in the range [0,1]
C cost of the regulated firm
CT total cost
CV variable cost
R revenue (or transfer)
P electrical energy
Q thermal energy
P* electrical energy obtainable with no thermal production
τ parameter characterizing the operational trade-off between thermal and electrical production

Subscripts

i,j product i and product j of a multi-product firm
MWhe electrical energy (MegaWatthour)
MWht thermal energy (MegaWatthour)

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