PLAYING THE GAME OF HEATING SYSTEMS. THE CASE OF ROMANIA

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Abstract

Although theoretically the individual decision of buying heating systems is expected to be an efficient choice, the problem of social sub-optimality must be considered. This paper models and empirically investigates, from the point of view of game theory and rational choice perspective, the distinction between individual and collective action, how the former can cause the failure of the latter. Individuals still choose to buy individual heating systems without being aware that a better solution is the investment in the modernization of centralized heating systems. Although it has a lot of beneficial aspects, as comfort or efficiency, the choice of individual boilers has important social negative externalities, such as neighborhood pollution. Therefore, the main inquiry is how public authorities can contribute setting the incentives to transpose individual rationality to the social level. The formal and game theoretical results show that if enough people cooperate in order to modernize district heating systems the both individual and social costs can be lower than in the case of individual heating boilers.

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CHAPTER 1: INTRODUCTION

One of the main challenges of technological development in those countries that use centralized heating systems is the increased number of individuals that decide to purchase individual heating systems. Thus, they have become responsible for the way common-pool resources, as gas, water, electricity and even clean air, are managed. Moreover, they have chosen and they still choose to invest in individual heating systems in a rational and selfish manner, without any regard to the social implications of their choice, as, for example, pollution.

The paper focuses on Central and Eastern European countries. The main emphasize is on Romania. However, the paper will make references to the case of Hungary in order to be able to formulate policy recommendation based on its best practices. The reason why we emphasize these two countries is twofold. First, both Romania and Hungary are post-communist countries that are very likely to share similar type of experience with regards to heating systems. Second, the two countries have adopted different mechanisms to regulate common-pool resources. Contrary to Romania, in Hungary, the District Heating Law stipulates that individuals can disconnect from the central system only if all flat users do so.[1] Moreover, Romania is only at the beginning of the implementation of regulation plans against over-consumption and pollution derived from heating systems.

While Hungary is a case in which disconnecting from the central system is associated with high costs[2], in Romania, over the last few years, there has been a steady increase in the number of individual purchases of heating systems. People have decided to give up the old

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[1] World Energy Council, Available at http://www.worldenergy.org/wec-geis/publications/reports/dh/foreword/exec_summ.asp, (accessed 24 February 2007);

[2] Katalin Pallai (ed.), *The Budapest Model. A Liberal Urban Policy Experiment*, World Bank Institute and Local Government and Public Service Reform Initiative, Budapest 2003, p. 261;

and inefficient system and get independent from the point of view of warmth, water and gas consumption. As the next table shows, the number of households connected to centralized heating systems decreases almost continually every year.

Table no.1 - The number of households connected to the centralized heating systems in Romania in the last four years

Year	The number of households connected to the centralized heating systems at the end of the year
2004	1.190.635
2005	1.113.093
2006	1.088.074
2007	1.082.628

Source: National Authority of Public Service Settlement for Communal Households[3]

Based on the above described situation, the main question this paper tries to explicitly answer is the following: which alternative – purchasing individual heating system or investing in the modernization of district heating system, induces a more effective management of common-pool resources and provides greater benefit at both the individual and social level? The two problems present in this question – the management of common-pool resources and the individual and social benefit, are interdependent and imply a single answer. The efficiency of the way common-pool resources are managed influences both the level of individual and social benefit. A secondary question this paper addresses is: How can public or political institutions intervene in the problem of heating systems in order to effectively manage common-pool resources? Considering these questions, the hypothesis of the paper is that *the modernization of district heating system is a more beneficial alternative to individual boilers at both individual and social levels*. Furthermore, I suppose that if enough individuals had had the possibility to cooperate in the game of modernizing the old area power station before they

[3] National Authority of Public Service Settlement for Communal Households (Autoritatea Nationala de Reglementare pentru Serviciile Publice de Gospodarie Comunala), Available at http://www.anrsc.ro/index/servicii_energetice/ARHIVA/arhiva_2007.htm, (accessed 15 May 2007);

started to disconnect, in the long run, their costs would have been lower than in the case of purchasing individual heating systems.

Since it is known that the modernization of heating systems is costly but very efficient and thus desirable, the results of this paper are predictable. However, my aim is to go more in depth and to empirically find the equilibrium of the game. In addition, giving the fact that the process of modernization of heating systems is irreversible, I claim that it becomes an issue that is related to all possible consumers. Consequently, I am proposing a new strategy for a better management of the renovation process, in which all individuals contribute to the investment.

The topic of this paper can be considered as new and challenging mainly because it combines elements of resource management, social preference aggregation, social choice and game theoretical modulation. Moreover, it provides a basis for knowledge accumulation regarding best practices and public policy making. Based on the experience of Hungary, the situation in Romania can be improved by adopting some models of overcoming the issue of heating systems, such as installing meters.

The issue of heating systems represents a practical concern in terms of the way individual choices negatively affect social outcomes like pollution and the way common resources are managed. Thus, by emphasizing the problem of heating systems and by formulating possible policy recommendations, the awareness of the negative aspects related to this issue can have a beneficial impact on public policy design.

From the methodological point of view, the paper aims to apply a formal and a game theoretical perspective. I will develop formal functions for each of the three heating systems considered – old district heating systems, individual heating systems and modernized district heating systems – that will comprise both financial (e.g. monthly maintenance costs and investment costs) and non-financial (e.g. comfort, control of the temperature, efficiency and externalities) factors. Based on these data, and since modernization of old heating systems is an irreversible process, the main emphasis is on the difference between individual heating systems and modernized ones within a collective game.

The relevance of the study is threefold. First, it is connected to the political science by dealing with the role of institutions within the social process. One of the main issues this paper focuses on is that, although at the individual level, the choices may be rational, at the social one, they are not anymore; individual rationality is not necessarily a pre-condition of social rationality. In this respect, the principle of methodological individualism states that since society is formed of individuals, its unitary shape cannot be explained unless individual behavior is taken into account.[4] Within the framework of this paper, it means that in order to have social optimality, the behavior of each individual in the community needs to be changed in order to choose the modernization of heating systems strategy. Large communities require intervention of an external coercive actor that, by aiming to maximize social utility, must guide each player's behavior.

Second, the economic perspective must be considered. With an average fixed monthly budget, individuals cannot be indifferent to the price they pay for common pool resources. Thus, by developing the issue of heating systems at both the individual and social level, the results might have a public policy application that can induce a higher level of welfare.

Finally, the analysis of individual heating systems is important because it raises the problem of pollution in urban areas and the lack of knowledge regarding this problem at the household level.

The structure of the paper is composed of two main parts: a theoretical one and an empirical one. The theoretical part tries to emphasize the importance of the way common-pool resources are managed and how the state can intervene in the process of collective action

[4] J. W. N. Watkins, "The Principle of Methodological Individualism", *The British Journal for the Philosophy of Science*, Vol. 3, No.10, Aug. 1952, pp.186-189;

in order to make it more efficient from both financial and non-financial perspectives. The empirical part focuses on developing a cost-benefit based description of each of the three heating situations – old district heating systems, individual heating systems and modernized heating systems. In addition, it provides a game theoretical perspective on the issue of heating by trying to reach an equilibrium and an optimal situation at the social level.

This paper has certain limitations that are going to be specified in the following paragraphs. First, although the initial idea has been developed from a comparative perspective between Romania and Hungary, the lack of data leads a focus on Romania. However, although this paper does not apply a comparative approach, it preserves the Hungarian case as an example of good practices.

Due to the fact that heating system is a complex issue, a second limit of the paper is the fact that game theory might not have all the tools in order to fully test the proposed model. Rational choice theory cannot explain the behavior of all individuals. People do not necessarily act rationally, by counterbalancing the alternatives and by choosing the optimal one in terms of individual benefits. Therefore, other aspects, as for instance bounded rationality, family or neighbors' networks and influence, social pressure or the skepticism about new technology might be relevant. However, although I am conscious of these shortcomings of rational choice theory, I still aim to treat the issue of heating systems from a rational choice perspective due to its most suitable approach in the analyzed issue. The choice between individual and centralized system is a matter of utility maximization.

Although it uses comparative statistics for the efficiency variable of the compared systems, this analysis cannot provide full quantifiable data for the comfort, control and externalities that characterize heating mechanisms. Thus, more in depth specialized studies may help describing the problem of comfort and of pollution derived from heating systems.

Third, one of the major difficulties is that official data regarding heating systems do not exist yet. Therefore, all the calculations I will develop are based on unofficial data or estimation.

Finally, as the aim of the paper is to test if individuals' investment in the modernization is a better alternative to households' boilers in terms of social benefits, public opinion could have been helped in developing a policy recommendation. Thus, conducting a survey at the national level might contribute in the future to complete the information available about modernization solution.

CHAPTER 2: CONCEPTUAL FRAMEWORK

This chapter aims to offer the conceptual tools needed in order to better understand and to clearly describe the issue of heating systems. Therefore, after defining common-pool resources, the paper is going to theoretically analyze the possible solutions for the tragedy of commons and see which of them can be better applied to the present problem. Moreover, as collective actions and externalities are strongly related to the way common-pool resources, as gas and water, are managed, a part of the conceptual framework is going to be allocated to them.

2.1 Common pool-resources

Development, broadly understood as demographic growth, growing demand for natural resources, integration of resources into the market, and technological innovations, increases the impact of human behavior on natural resources. Edwards and N. A. Steins argue that this development leads to "overexploitation, alienation of traditional users groups and conflict among different stakeholders".[5]

In trying to answer the question which is the most appropriate authority that must and can manage common-pool resources, a description of "*the common-pool resource*" concept is required. Contrary to private goods owned by a single person, common-pool resources are those resources that do not exclude anyone from using them, but that do not permit multiple consumers to use the same good for unlimited time.[6] In other words, as Heikkila claims, common-pool resources present the difficulty in excluding users and sub-tractability of

[5] V. M Edwards and N. A. Steins, "Developing an Analytical Framework for Multiple-Use Commons", *Journal of Theoretical Politics*, no.10 (3), 1998, pp. 347-383, in Nathalie A. Steins and Victoria M. Edwards "Synthesis: Platforms for Collective Action in Multiple-Use Common-Pool Resources", *Agriculture and Human Values* no.16, 1999, Kluwer Academic Publishers, p.309;

[6] Elinor Ostrom, Roy Gardner, and James Walker, *Rule, Games, and Common-Pool Resources*, (Michigan: The University of Michigan Press, 1994), p.4;

supplies (which can lead to problems of free-riding or insufficient maintenance of supplies), where each resource user reduces the supply available to others (which can lead to problems of over-appropriation or congestion).[7] Therefore, "tragedy of commons"[8], as Hardin named it, may arise mainly because "human behavior is driven by the maximization of individual payoffs and not by the desire to achieve a social optimal solution".[9]

In sum, common-pool resources, in the case of the discussed topic, are mainly gas, water and air. All these need to be properly managed in order to have both quality and efficiency of consumption. Moreover, due to the fact that heating systems refers to large communities, the likelihood that people will cooperate one with another are minimal. Therefore, external incentives are needed in order to induce an efficient management of common-pool resources.

2.2 The management of common-pool resources

The literature has tried to find the proper solution to the problem of common pool resources and to give further public policy significance to the issue. The most viable solutions for the tragedy of commons, found in the literature, are central authority management, market or private property management, and self-management. However, all of them have shortcomings that may affect the decision-making process in the long run.

The first solution that can be brought into discussion related to the issue is the extent to which a *central authority or public institutions* can create incentives to induce rational behavior at the social level in order to maximize general welfare. Thus, in the case of

[7] Tanya Heikkila, "Institutional Boundaries and Common-Pool Resources Management: A Comparative Analysis of Water Management Programs in California", *Journal of Policy Analysis and Management*, Vol. 23, No.1, 2004, Published by Wiley Periodicals, p.100;
[8] Garrett Hardin, "The Tragedy of the Commons", *Science* (162), 1968, pp. 1243-1248;
[9] Maria-Elisabeth Fischer, Bernd Irlenbusch and Abdolkarim Sadrieh, "An Intergenerational Common Pool Resource Experiment", *Journal of Environmental Economics and Management*, No. 48, 2004, p. 811;

common pool resources, the State may have an important role in shaping the ways in which users of such goods "coordinate their actions to solve supply and demand dilemmas".[10]

Institutions are able to formulate norms, rules or laws to regulate behavior, in a formal or informal manner. Thus, coercion might be the instrument that regulates individuals' behavior in such a manner that, through punishment, it leads to social consciousness. Olson claims that in the absence of coercion, the collective action of the members in a group managing common pool resources will not lead to an efficient social outcome and rational self-interested individuals will not maximize their common economic interests.[11] In the same manner, Ophuls refers to the same solution of coercion, sustaining that only public control over common pool resources will align in an efficient way members' behavior.[12] However, Hardin recommends only "mutual coercion", agreed by the majority of people.[13]

However, a part of the literature seeks to critique the central authority's capacity to efficiently manage common-pool resources. For instance, the collapse of state authority can lead to little political authority or ability to establish the rule of law.[14] Furthermore, Elinor Ostrom underlines the fact that central authority intervention cannot be efficient because the punishment may not work in case of an indifferent individual, and because, under incomplete information, the State may punish cooperators instead of defectors.[15]

The second possibility for solving the problems of common-pool resources is defined in the literature as the privatization of these goods. Antonio Nicita sustains the de-centralized solution or market solution, which means that only the re-allocation of property rights over

[10] Tanya Heikkila, op. cit., pp. 97-117;
[11] Antonio Nicita, "Incomplete Contracts and the Commons: Valuing the Strategic Role of Existing Costs", *Italian Antitrust Authority and University of Siena*, 1999, p. 2;
[12] W. Ophuls, "Leviathan or Oblivion" quoted in Antonio Nicita, op. cit., p. 3;
[13] Garrett Hardin, op. cit., p. 1247;
[14] Garry King and Langche Zeng, "Research Note. Improving Forecasts of State Failure", Available at http://gking.harvard.edu/files/civil.pdf, (accessed 24 November 2006);
[15] Elinor Ostrom, *Governing the Commons*, (Cambridge: Cambridge University Press, 1990), pp. 10-11;

common pool resources will induce members to reduce the gap between private benefit and collective costs.[16]

However, besides state failure, market failure seems to be an important aspect that needs to be taken into account. In this respect, one of the most important assumptions is that, within a competitive market in which every player is self interested, the distribution of a commodity cal lead to social inefficiency[17]. Naidu sustains that "state-market solutions" do not recognize that individuals in a community interact with each other to make mutually advantageous decisions.[18] In this context, it is also important to consider that when a resource is held in a common among a community of users, "every user has the incentive to exploit the resource at the level that is collectively inefficient"[19]. Moreover, by being a competitive market, by formulated opportunities for those who can or want to invest, the private market does not seem to solve the problem of social lack of optimality. More than that, the state lack of involvement leads to incapacity of self-regulation. For instance, the buildings associations are incapable to provide regulations in order to self manage the available resources.

Besides the above mentioned possible solutions that might improve the situation of commons, a third solution must be considered: *self management* or the power of community members to govern their own common pool resources. This idea is mainly emphasized by Ostrom, who claims that it is easier to monitor the situations mainly because individuals are insiders.[20] Based on the same idea, Falk, Fehr and Fischbacher sustain that in many situations, people are able to cooperate and improve their joint outcomes, by financially or non-financially sanctioning each other without the intervention of a third actor. However, in the

[16] Antonio Nicita, op. cit., p. 3.
[17] Julianle Grand, "The Theory of Government Failure", *British Journal of Political Science*, Vol.21, No.4, October, 1991, pp. 423-442;
[18] C. Sirisha Naidu, "Heterogeneity and Common Pool Resources: Collective Management of Forest in Himachal Pradesh, India", Department of Resource Economics, University of Massachusetts Amherst, 2005, p. 3;
[19] Nicolas Faysse, "Coping with the Tragedy of the Commons: Game Structure and Design of Rules", *Journal of Economic Surveys*, Vol.19, No.2, Blackwell Publishing Ltd., 2005, p. 239;
[20] Elinor Ostrom, op. cit., pp. 23-24.

case of voluntary self-management, they bring two concepts into discussion that need to be considered: reciprocity and selfishness. From the point of view of the authors, on the one hand, reciprocity means that the subjects act cooperatively as long as the others are nice and cooperative too, while if others are hostile, they retaliate (no cheating alternatives). On the other hand, selfish people follow their own interest without counting the negative externalities they impose on others. This kind of solution is plausible in small groups but it is unlikely to function at the level of a community, where people cannot communicate face to face, cannot negotiate.[21]

However, some problems may also arise in the effort of collective management of common-pool resources. Sproule-Jones considers that individuals within a community may have different perceptions of the costs and benefits of *collective action,* while they may also disagree about the need for a shift into a collective activity if they are satisfied in terms of individual benefits.[22] Moreover, the size of the community is also important. Olson sustains that one of the differences between small and large groups is that in small groups the participation of every individual matters and affects the entire group and his/her actions are noticed, while in large groups, individual impact is negligible.[23] This is the reason why, in large groups, rational individuals are very likely to act as free riders.

Beside the free riding issue, there is the issue of aggregation procedure, which means that there must be a rule that tells what the collective preference is.[24] Heap *et al.* claim that it is very likely to have a certain level of disagreement regarding the set of action that is more

[21] Armin Falk, Ernst Fehr and Urs Fischbacher, "Appropriating the Commons-A Theoretical Explanation", *Center for Economic Studies and Info Institute for Economic Research*, May 2001, p. 2;
[22] Mark Sproule-Jones, "Toward a Dynamic Analysis of Collective Action", *The Western Political Quarterly*, Vol. 26, No. 3, September, 1973, p.424;
[23] Douglas D. Heckathorn, "The Dynamics and Dilemmas of Collective Action", *American Sociological Review*, Vol.61, No.2, April 1996, p. 251;
[24] John H. Smith, "Aggregation of Preferences with Variable Electorate", *Econometrica*, Vol. 41, No. 6, 1973, p.1028;

beneficial to follow.[25] In addition, I would say that, given the entire society, even a partial agreement between the members of community is not plausible without the intervention of an external authority that can narrow the actions to a certain direction, mainly through coercion. Arrow claims that there are two methods by which social choices can be made in capitalist democracies: “political” and “economic” decisions[26]. In the same respect, Olson emphasizes the fact that the increasing nuisance of externalities due to urbanization and implicitly to technological advance can be managed only by governmental intervention.[27] Furthermore, considering that individuals are rational, or at least intentionally rational, and that they will probably follow their own interest, an external actor that can transpose individual rationality at the social level must come into play. This actor is very likely to be central authority mainly because it has both the necessary information and means in order to evaluate the general situation, to find the best solutions and to implement them in such a way that can increase the overall level of welfare.

Considering the aforementioned theoretical solutions for the management of common-pool resources, and the issue of heating systems being a very complex problem, the main solution of the empirical part is going to focus on the public authority intervention. The main reason is the fact that public authority is the only actor that can provide the highest source of control at the social level in order to increase the potential of social optimality.

[25] Shaun H. Heap, Martin Hollis et al., *The Theory of Choice. A Critical Guide*, (Blackwell Oxford UK and Cambridge USA, 1992), p. 206;
[26] Kenneth J. Arrow, *Social Choice and Individual Values*, Second Edition, (New Haven and London: Yale University Press, 1963), p.1;
[27] Mancur Olson in David Reisman, *Theories of Collective Action. Downs, Olson and Hirsch*, (London: Macmillan Press, 1990), p. 154;

2.3 Collective action

Although the management of common-pool resources is believed to be properly done using external intervention, collective action and the way the members of community interact remains an important issue mainly because of its linkage with free riding problem. Therefore, a brief description of the theoretical argument needs to be presented. Jeff Dayton-Johnson and Pranab Bardhan consider that the management of common-pool resources is a "collective-action dilemma: a situation in which mutual cooperation is collectively rational for the group as a whole, but individual cooperation is not necessarily rational for each member".[28]

One of the multiple definitions of collective action presented in the literature is given by Holzinger. She claims that collective action refers to "the joint actions of a number of individuals that aim to achieve and distribute some gain through co-ordination or co-operation"[29]. Thus, it is generally accepted that collective action implies cooperation and collaboration between the members of a community. However, cooperation is believed to depend on the obligations and on the degree of compliance with these obligations.[30] While the former depends on the cost of producing common goods and on members' independence, the latter depends on the sanctioning capabilities of the group.

Oliver talks about four different levels of collective action.[31] The first one refers to every individual separately and it is concerned with his/her contribution to the action. Second, there is the model that focuses on the question whether individuals are able to coordinate their own actions into a single one. The third level is concerned with the collective decision process

[28] Jeff Dayton-Johnson and Pranab Bardhan, "Inequality and Conservation on the Local Commons: A Theoretical Exercise", *The Economic Journal*, 112 July, pp.577-602, Royal Economic Society 2002, Published by Blackwell Publishers, p.577;
[29] Katharina Holzinger, "The Problems of Collective Action: A New Approach", Gemeinschaftsgüter: Recht, Politik und Ökonomie, Bonn, January 2003, p.2;
[30] A. Hechter, "The Attainment of Solidarity in International Communities", *Rationality and Society,* 2(2):142-155,1990 in Naidu, C. Sirisha, "Heterogeneity and Common Pool Resources: Collective Management of Forest in Himachal Pradesh, India", Department of Resource Economics, University of Massachusetts Amherst, p.5;
[31] Pamela E. Oliver, "Formal Models of Collective Action", *Annual Review of Sociology*, Vol.19, 1993, pp.271-300;

and with which subset of action is going to be chosen by the members of the group. Finally, there is the model that aims to understand the interaction between different groups or collective entities.

Considering the above description of collective action, it is also important to focus on the way the theoretical framework can be put in practice and the problems that can emerge from such interactions. A part of the literature classify the possible problems of collective action into two categories: problems of coordination (solved through non-cooperative or political mechanisms) and problems that involve conflicts and that can be best solved through collective and coercive means.[32] Continuing this classification, a typology of games that imply collective actions problems could be developed: harmony games, which do not imply collective action problems, conflict or inequalities between players; games that have a second Pareto-optimal outcome, which differ from an equilibrium; pure conflict games characterized by lack of equilibrium, inequality between players and instability; games characterized by defection problem with a unique Nash sub-optimal equilibrium, with partial conflict between individual and collective rationality (e.g. Prisoners Dilemma); co-ordination games in which there are multiple equilibria in pure strategies and which are not conflict games; games with disagreement problems that have two Pareto-optimal equilibria in pure strategies (e.g. The Battle of Sexes); and non-coordination games which have neither pure strategy Nash equilibria nor Pareto optimality and which are characterized by instability.[33]

Besides the above mentioned issues, the literature emphasizes other two fundamental problems regarding collective action. First, there is the concern with the fact that action may spontaneously spring only under extreme conditions of consensus among individuals' goals –

[32] Katharina Holzinger, "The Problems of Collective Action: A New Approach", Gemeinschaftsgüter: Recht, Politik und Ökonomie, Bonn, January 2003, p.25;
[33] *Ibid.*, pp. 12-16;

individuals must desire the same course of action.[34] Second, there is the contingency issue, which claims that the benefit for one party depends on the participation of other parties.[35]

Furthermore, the issue of cost within a collective decision must be considered. First there are costs related to the fact that collective decision might not correspond to individual preferences, and second there are costs related to the decision-making process, as time and effort of bargaining in order to reach a consensus.[36] Collective action is not described as meaning that every single individual within a community is engaged in the process, but that enough people that have similar interests are connected.[37] Moreover, it must be taken into account the fact that the cost of cooperation might differ from one individual to another.[38]

Following the idea of tragedy of commons, another issue that is related to common-pool resources and that needs to be discussed is the free-riding problem. The free-rider problem may be considered a logical choice considering that rational and self-interested individuals will not participate in collective action when the impact of every individual is negligible and the benefit of collective action is public and free for anyone[39]. Therefore, it may be claimed that a rational individual is by definition a free rider. In addition, the literature emphasizes the fact that people fail to participate in collective actions not because they want to be free riders but because they expect the failure of a certain action and, therefore, they do not believe in such cause.[40] At the same time, individuals try to get conscious about the costs

[34] James S. Coleman, "Foundations for a Theory of Collective Decisions", *The American Journal of Sociology*, Vol.71, No.6, May, 1966, pp.615-627;
[35] *Ibid.*, pp.615-627;
[36] Mark Sproule-Jones, "Toward a Dynamic Analysis of Collective Action", *The Western Political Quarterly*, Vol.26, No.3, September, 1973, p.414;
[37] E. Schlager and V. M. Bloomquist, "A Comparison of Three Emerging Theories of the Policy Process", *Political Research Quarterly*, 49 (3), September, 1996, pp.651-672 in Naidu, C. Sirisha, "Heterogeneity and Common Pool Resources: Collective Management of Forest in Himachal Pradesh, India", Department of Resource Economics, University of Massachusetts Amherst, p.6;
[38] *Ibid.*, p.5;
[39] Byron Miller, "Collective Action and Rational Choice: Place, Community, and the Limits to Individual Self-Interests", *Economic Geography*, Vol.68, No.1, Rational Choice, Collective Action, Technological Learning, January, 1992, pp.22-42;
[40] Douglas D. Heckathorn, "The Dynamics and Dilemmas of Collective Action", *American Sociological Review*, Vol.61, No.2, April 1996, p.252;

and benefits of their actions and they weigh the value of collective goals in relation to the likelihood of achieving those goals[41].

However, as it is going to be illustrated in the following section, this situation can partially be changed through coercion, as sanctions for nonparticipation in common actions. Besides that, as DeNardo stresses, there are at least two other possibilities: overestimation of the importance of their participation in collective action and the opportunity to meet other people. [42] Both situations can increase the utility to participate. Taylor and Elster propose another solution, namely the incorporation of time into the Prisoner's Dilemma game. This can lead to mutual cooperation by engaging selfishly rational cooperative action as "I will cooperate only if you cooperate too".[43]

However, considering all these aspects, the size of the analyzed group must also be mentioned. Thus, as Olson sustains, one difference between small and large groups is that while in the former ones every individual's action affects the entire group, in the latter situation, the individual's impact is negligible and free riding is more likely to happen.[44] Furthermore, Oliver and Marwell claim that large groups are not less likely than smaller ones to support collective action. They sustain that the group size depends on costs of cooperation and that if the cost varies little with the group size, larger groups should be part of more collective actions because of the resources they own.[45] In addition, as Olson and Hardin claim, group homogeneity has a positive effect on the prospects for collective action.[46]

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[41] Laura Shill Schrager, "Private Attitudes and Collective Action", *American Sociological Review*, Vol.50, No.6, December 1985, pp.858-859;

[42] DeNardo in Byron Miller, op. cit., p.25;

[43] Byron Miller, op. cit., p.26;

[44] Douglas D. Heckathorn, "The Dynamics and Dilemmas of Collective Action", *American Sociological Review*, Vol.61, No.2, April 1996, p.251;

[45] Pamela E. Oliver and Gerald Marwell, "The Paradox of Group Size in Collective Action: A Theory of the Critical Mass.II", *American Sociological Review*, Vol.53, No.1, February 1988, pp.1-8;

[46] Olson and Hardin in Pamela E. Oliver and Gerald Marwell, "The Paradox of Group Size in Collective Action: A Theory of the Critical Mass.II", *American Sociological Review*, Vol.53, No.1, February 1988, p.4;

Collective action implies collective decision-making too. In this case, expectancy is a very important concept. Louis and Taylor assume that "individuals who strongly identify with a group derive the individual-level costs and benefits that drive expectancy-value processes ("rational" decision-making) from group-level costs and benefits".[47]

Considering all the above mentioned aspects, it can be claimed that although heating system is an issue that might be solved through legal coercion, collective action can still play an important role in the coordination of people's decisions. Moreover, it can be said that public authority can effectively induce a state of social welfare only in the context in which individuals cooperate and collectively assess the importance of a certain decision, as, for instance, that of investing in the modernization of district heating systems.

2.4 Externalities

Heating systems are machines that function by using gas. Therefore, as the literature claims, there are two types of pollution associated with these systems: interior pollution and exterior pollution.[48] While the former refers to the usage of methane gas, the latter is related to the positioning and the dimensions of smokestacks. Placing these smokestacks horizontally, the air currents facilitate the circulation of polluted substances in the neighborhood, thus creating an overlaying of polluted air. It is also acknowledged that the increasing of central heating systems' number in medium run will raise the global warming effect.

Considering the aforementioned aspects, the concept that needs to be theoretically described is that of externality or "spill-over effect" [49]. Externality can be defined as follows:

[47] Louis Winnifred, and Taylor Donald, "Cost-benefit analyses for your group and yourself: The 'Rationality' of decision-making in conflict", draft version, April, 2003, p.2;
[48] Douglas Fowler, The Institute of Environment Overseen from Richmond, California, in Media Uno, 8 December 2005, Available at http://www.mediauno.ro/rci-search.php?art=2964, (accessed 20 April 2007);
[49] Daniel Brook, "The Ongoing Tragedy of the Commons", *The Social Science Journal,* 38 (2001), pp. 611-616;

"an activity on the part of one party that enters directly into another party's utility or production function"[50]. In addition, based on general definitions of externalities, the literature stresses that in capitalist societies, non-market goods that are imposed by the market activities creating services or disservices to people and to the environment.[51] Although there can be both positive and negative externalities, this paper is going to refer only to the latter ones as for instance pollution or uncompetitive market, because they are strongly related to the idea of individual heating systems. Therefore, considering this type of externality, it can be claimed that both it is about individual gain and social loss, and that it is a negative "invisible punch" that corresponds to the point at which capitalists profit at the expense of the common goods.[52]

Furthermore, social utility can be linked with social welfare by considering that individual benefit does not necessarily produce social benefit unless negative effects and costs are minimal. In this situation, Randall claims that externality occurs when individual's utility is influenced by the activity of others[53]. Moreover, Mishan[54] claims that even under perfect competition, a market organization of the economy can lead to a non-Pareto optimal outcome if the externalities are present. Furthermore, as Hardin claims, negative externalities have no technical solutions. In contrast, they need morality – although it is not an intended action, polluting is rarely an unknown action - , which does not characterize the market.[55] Thus, if we consider pollution as the main externality in this paper, we may say that solutions for the aforementioned problem must be found outside the market system.

[50] Cecil Bohanon, "Externalities: A Note on Avoiding Confusion", *The Journal of Economic Education*, Vol.16, No.4, Autumn 1985, p.305;
[51] Daniel Brook, op. cit.;
[52] *Ibid*., p.612;
[53] Laura M. J. McCann , "Accounting for Societal Externalities", Department of Agricultural Economics University of Missouri, Columbia, Text of selected paper for the Association of Social Economics World Congress, Albertville, France June 8-11 2004, Available at http://socialeconomics.org/uploads/McCann.pdf, (accessed 20 February 2007);
[54] Mishan in Peter Bernholz, "Externalities as a necessary Conditions for Cyclical Social Preferences", *The Quarterly Journal of Economics*, Vol.97, No.4, November 1982, pp.699-705;
[55] Daniel Brook, op. cit., p. 614;

Strongly related with the externality problem is the neighborhood aspect of social life, also known as neighborhood effects. Thus, proximity becomes an important cause of negative externalities[56]. Living in a neighborhood implies the fact that individuals are affected by the behavior of others. This effect occurs "when an individual's household's characteristics or action affect their neighbors' behaviors or socioeconomic outcomes".[57]

In sum, the conceptual framework is intended to introduce the basic concepts that are going to be used at the empirical level and to shape the main ways the literature deals with them. Moreover, by describing common-pool resources, the way they can be managed, the importance of collective action within the process and the possible negative outcomes of using certain techniques, I have tried to emphasize the main issues that are related with heating systems. Therefore, based on the theoretical tools offered, the following parts of the paper will provide empirical evidence and data about heating systems in order to sustain the aforementioned hypothesis.

[56] Eliakim Katz and Uriel Spiegel, "Negative Intergroup Externalities and Market Demand", *Economica*, New Series, Vol.63, No.251, August 1996, pp.513-519;
[57] Donald R. Haurin, Robert D. Dietz, Bruce A. Weinberg , "The Impact of Neighborhood Homeownership Rates: A Review of the Theoretical and Empirical Literature", Department of Housing and Urban Development, March 2002, p.4;

CHAPTER 3: HEATING SYSTEMS IN ROMANIA AND HUNGARY

This chapter consists of a comprehensive description of the *status quo* in which Romania and Hungary find themselves, from the heating systems perspective. While the first part of the chapter will be a general description of the way heating systems are perceived mainly in transitional economies, the last two will specifically deal with the cases of Romania and Hungary and their heating situation. Although Hungary is not part of the empirical analysis, its situation might give an important idea about the way the issue of the Romanian heating system can be improved.

3.1 A general framework

While this paper aims to analyze the difference between remaining connected to district heating systems by investing in their modernizations and investing in an individual heating system, it is important to have an overall background regarding heating systems in general and of the possible related issues. The main sources used in this description are Energy Charter Protocol on Energy Efficiency and International Energy Agency. Therefore, the main focus of this part will be more on why old district heating systems should be modernized and less on the difference between the latter and individual heating systems. While individual heating systems are the boilers entirely owned by householders and that can be individually controlled in terms of temperature and consumption, district heating are centralized neighborhood plants that distribute heat to a large number of buildings.

District heating is an important issue in transition countries mainly due to the fact that it covers around 60% of heating and hot water needs.[58] However, the main problems related to

[58] International Energy Agency, “Coming in from the Cold. Improving District Heating Policy in Transition Economies”, OECD/IEA, 2004, pp.15-16;

district heating in these countries are believed to be old heating networks, poor quality of heating, and high tariffs.[59] Most individuals prefer alternative solutions in order to improve their situation, as, for instance, purchasing individual heating systems. It is claimed that given that only those who cannot afford to invest in an individual heating system remain connected and more and more people prefer to disconnect themselves from the centralized system, the sustainability of district heating may be threatened.[60]

The pollution issue must be considered too. Having in mind that an old electric system sends out almost 3-5 tones of polluted substance on hour, the modern technologies on environmental protection, using "cold plasma" in order to reduce the quantity of sulfur and azote, might be a solution.[61] Specialized studies indicate that the main part of CO2 – the gas responsible for global warming – is due to energy production.[62]

Regarding the regulation issue, the specialized literature makes a distinction between completely regulated markets or not regulated at all.[63] A difference is made between transitional economies in which district heating systems are *production driven* (characterized either by excess of heat during warm seasons or by lack of heat during cold seasons) and developed democracies or market economies in which district heating systems are *demand driven* (characterized by automatic control of the temperature in accordance with buildings' specific needs).[64] Based on these assumptions, specialists have identified a main option in order to improve the district heating situation: the modernization of old district heating

[59] Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA), Energy Charter Secretariat, "Cogeneration and District Heating. Best Practices for Municipalities", Belgium, 2005, p.21;
[60] *Ibid.*, p.21;
[61] "Energetica" Magazine – The Scientific and Technical Association of Energy Scientists in Romania (Asociatia Stiintifica si Tehnica a Energeticienilor din Romania), August-September, 2001
[62] Regional Report on the Environment Conditions in the N-W Region, 2005, Available at http://www.arpmnv6.ro/Programe%20de%20aderare/Cap%2010%20Reg%206%20Rap%2005.pdf, (accessed 20 February 2007);
[63] Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA), Energy Charter Secretariat, "Cogeneration and District Heating. Best Practices for Municipalities", Belgium, 2005, p.25;
[64] *Ibid.*, pp. 40-41;

systems, which can lead to lower costs and high heating quality and thus keep consumers in the system and even attract new ones.[65]

The specialized literature emphasizes that there are at least three reasons why district heating systems need modernization: to improve energy efficiency, reduce heating costs and reduce nocive emissions.[66] Although district heating systems are able to provide low costs and low levels of pollution[67], there is a large number of issues that must be solved, as inefficient production or declining sales.[68] One could mention the decreasing number of consumers, low efficiency, system losses that can be as high as 30%[69], the lack of focus on the demand for heat and high distribution costs[70].

As part of the modernization process, heat metering and thus temperature control can increase the efficiency of the system and save energy.[71] A wise price regulation can increase district heating systems competition.[72] As the table below shows, there is significant difference between the two types of district heating system regarding the amount of consumption and the price.

[65] *Ibid.*, p.44;
[66] *Ibid.*, pp. 40-41;
[67] It is estimated that, based on a strong policy framework, district heating systems found in transition countries, can save the equivalent of 80 billions cubic meters of natural gas per year, which means that that gas emissions will be reduced by 350 million tons of carbon dioxide per year, International Energy Agency, "Coming in from the Cold. Improving District Heating Policy in Transition Economies", OECD/IEA, 2004, pp.15-16;
[68] International Energy Agency, "Coming in from the Cold. Improving District Heating Policy in Transition Economies", OECD/IEA, 2004, pp.15-16;
[69] *Ibid.*, pp.19-20;
[70] Dimtcho Gueorguiev Linkov, "Energy Efficiency of Space Heating in District Heated Buildings in Bulgaria", MA Thesis submitted to the Department of Environmental Studies, Central European University, Budapest, August 1998, p.37;
[71] Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA), Energy Charter Secretariat, "Cogeneration and District Heating. Best Practices for Municipalities", Belgium, 2005, p.26;
[72] *Ibid.*, p.25;

Table no. 2 – The difference between old and modern district heating systems in general in terms of energy consumption and costs[73]

Energy Economy of DH	Old		Modern		Unit
Fuel energy		175		117	MWh
- combustion losses	15%	26	8%	9	MWh
- to network		149		108	MWh
- transmission losses	20%	30	7%	8	MWh
- to customers		119		100	MWh
- loss of poor regulation	16%	19	0%	0	MWh
A. Heat energy to customer		100		100	MWh
Costs					
- fuel price	20		20		euro/MWh
- fuel cost for heating		3,500		2,340	euro
- sales margin	10%	350	10%	234	euro
B. Customer's energy cost		3,850		2,574	euro
Unit cost for customer	B/A	38.5	B/A	25.7	euro/MWh

Source: Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA)

The data indicate that the difference between old and new heating systems is relatively high in regards to energy losses and costs. It can be claimed that investing in the modernization of the old district heating system induces, at least in the long run, a more efficient way of managing energy, from both financial and non-financial points of view. Specialized studies indicate that the efficiency of a heating system, besides the fact that they depend very much on the conditions of distribution, is around 35% but can increase to 80% if modernization takes place.[74]

District heating issue in general and modernization of heating system in particular is believed to be an urgent problem due to the old state of the heating machines.[75] Even European legislation strongly supports the benefits of the modernized district system due to its

[73] *Ibid.*, p.43;
[74] Dimtcho Gueorguiev Linkov, "Energy Efficiency of Space Heating in District Heated Buildings in Bulgaria", MA Thesis submitted to the Department of Environmental Studies, Central European University, Budapest, August 1998, p.7;
[75] A Promotional Program for District Heating in Candidate Countries and Pilot Actions in Hungary and Romania (DHCAN), Available at http://www.euroheat.org/workgroup4/, (accessed 6 May, 2007);

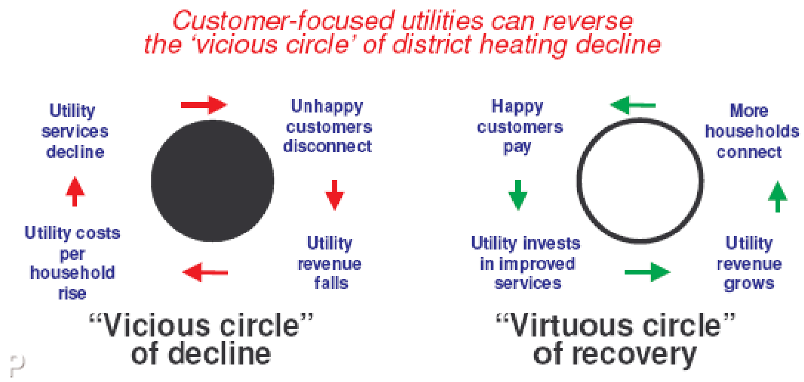
efficiency, its savings possibilities and thus, its emission reduction.[76] While modernized district heating, based on combined heat and power (CHP), shares around 64% to 94% of the western EU members' market and raises to 72% in the rest European countries, as Hungary, the savings of this system are estimated to be around 65% compared to the old system.[77]

Furthermore, due to the fact that the energy efficiency is higher and the losses are believed to be lower within a CHP system, and due to the fact that the share of district heating in Central and Eastern Europe is around 37%, the most proper solution in order to increase the efficiency of the system, proposed by the specialized literature is to increase the share of the cogeneration supply.[78] As mentioned in the previous chapters, the most cited advantages of the district heating system are: higher energy efficiency and efficient combination of electricity and heat.[79] In addition, modernization implies an environmentally friendly technology that emits smaller amounts of pollution and that have better technology and strategy as, for instance, using higher chimneys.[80]

The figure below[81] emphasizes that there is a significant difference between old centralized heating systems and modernized ones. Furthermore, the difference refers both to the utility derived from using a certain type of heating system and to the way consumers may perceive their situation.

[76] Ecoheatcool, "Guidelines for Assessing the Efficiency of District Heating and District Cooling System", , Work Package 3, A Euroheat and Power Initiative, supported by the Intelligent Energy Europe, Belgium, 2005-2006, p.10, Available at http://www.euroheat.org/ecoheatcool/project_3.htm, (accessed 7 May, 2007);
[77] *Ibid.*, p.7;
[78] The International Association for District Heating, District Cooling and Combined Heat and Power, "The Case for District Heating: 1000 Cities Can't be Wrong! A Guide for Policy and Decision Makers", pp.10-14, Available at http://www.euroheat.org/ecoheatcool/project_3.htm, (accessed 7 May, 2007);
[79] *Ibid.*, p.14;
[80] *Ibid.*, pp.16-17;
[81] Mark Velondy, Project Manager UNDP/GEF Energy Efficiency Financing Team, Conference on "Energy Efficiency – Releasing the Investment Potential. Capacity Building for GHG Emissions Reduction through Energy Efficiency in Romania", Bulgaria, 2006;

Figure no. 1 – The difference between old district heating systems and modernized ones



Source: Conference on "Energy Efficiency – Releasing the Investment Potential. Capacity Building for GHG Emissions Reduction through Energy Efficiency in Romania"

Important advantages of the district heating systems mentioned in the specialized literature are the following ones: lower emissions, higher efficiency (less energy is needed) due to cogeneration[82] system, the possibility of using energy from different sources, energy security, economic development promotion due to competitiveness (rational pricing and high quality).[83]

Considering all aforementioned aspects, it can be claimed that the quality of improvements depends on the way public policies are designed and enforced. It is argued that besides the efficiency of services, policies can improve the sustainability of the entire industry, mainly by giving greater priority to the demand not only to production.[84]

[82] Cogeneration means a "technological process of combined production of heat and power for industrial or domestic use" in Modernization of Heating Systems Based on Small/ Medium CHP", Guide 2004, ASA Holding Romania and The Romanian Agency for Energy Conservation (ARCE) Romania;
[83] International Energy Agency, "Coming in from the Cold. Improving District Heating Policy in Transition Economies", OECD/IEA, 2004, pp.17-18;
[84] *Ibid.*, pp.16-17;

3.2 The Romanian heating systems

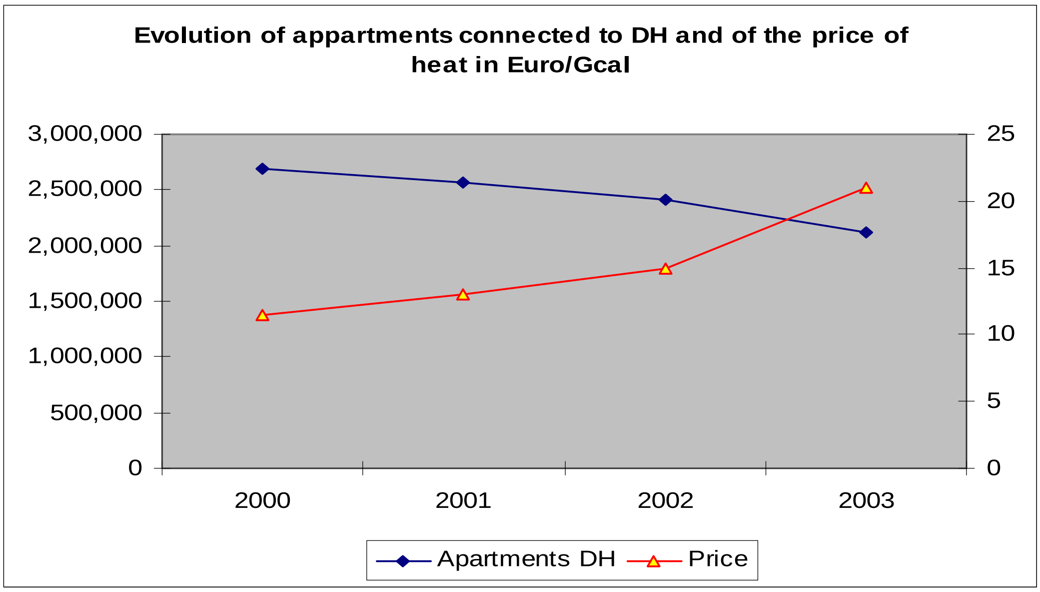
Romania is characterized by 31% supplies of the heat market from the district heating with Termoelectrica Company supplying more than 63% of the heat production.[85] Although it is believed that individual heating systems offer a large number of advantages, the specialized literature claims that district heating systems are more reliable than individual boilers, at least in the case of Romania.[86] That is one of the reasons why some cities in Romania have been witnesses of explosions caused by the improper use or construction of individual heating systems. While the costs of maintaining district heating are included in the monthly price, it is admitted that individual heating systems need extra maintenance due to the risks coming from inadequate installing or lack of yearly control.[87] Furthermore, although there are measures in order to protect the environment mainly regarding district heating, as the Law no. 137 for the Protection of the Environment, and to save energy[88], there is a large amount of pollution produced by individual boiler systems.

The danger is believed to be higher mainly because many people demand less and less services from the centralized heating offices, due to poor quality or high prices, and switch from district heating to other forms of heating, as it is the individual boiler one.[89] The average of disconnection in Romanian counties may be more than 30% in some parts of the country.[90] Official data say that 70 of 250 Romania's district heating systems have collapsed.[91] In addition, as the figure below shows, in the case of Romania, while the number of households

[85] Madalina Anastasiu, Institute for Studies and Power Engineering, The case of Romania, in *District Heat in Europe. Country by Country/ 2003 Survey*, Published by EUROHEAT & POWER, The International Association for Combined Heat and Power, District Heating and District Cooling, Belgium 2003, pp. 301-302;
[86] International Energy Agency, "Coming in from the Cold. Improving District Heating Policy in Transition Economies", OECD/IEA, 2004, pp.39-40;
[87] *Ibid.*, pp.132-133;
[88] Madalina Anastasiu, op. cit., p. 303;
[89] International Energy Agency, "Coming in from the Cold. Improving District Heating Policy in Transition Economies", OECD/IEA, 2004, pp.51-52;
[90] *Ibid.*, p. 68;
[91] *Ibid.*, p.65;

disconnected from the centralized heating system is decreasing, the consumption prices increase.[92]

Figure no. 2 – The evolution of district heating connections and prices in Romania



Source: APICT – The Association of Producer and Importers of Heating System (Asociatia producatorilor si importatorilor de centrale termice), Individual Heating System – Study Case

The case of Romania is a special one because of the ineffectiveness of applying certain regulations. Although it was legally framed that if the production and the distribution costs will outrun the national reference price previously established by the National Energy Regulatory Agency (ANRE), local and national budgets will subsidize the difference, in most of the cases, this did not happen.[93] In Romania there is a double regulation of heat - municipalities regulate the heat produced from "heat-only boilers" and at the national level regulation is focused on heat produced from cogeneration - that complicates the situation very

[92] APICT – The Association of Producer and Importers of Heating System (Asociatia producatorilor si importatorilor de centrale termice), Individual Heating System – Study Case, Available at http://www.apict.info/statistici.htm, (accessed 6 May 2007);
[93] International Energy Agency, "Coming in from the Cold. Improving District Heating Policy in Transition Economies", OECD/IEA, 2004, pp.98-99;

much by increasing the likelihood of conflict of interest.[94] The disconnection issue is believed to have social, economic and environmental consequences.[95]

In sum, it can be claimed that the case of Romania is an interesting and socially irrational one. A large number of people give up on the district heating system due to its inefficiency and high costs. Most of them prefer to invest in individual heating systems. This situation is a matter of counterbalancing between two known systems: a system that is known as being characterized by lack of efficiency and a system that offers larger benefits but that is not known entirely. Thus, while the former case is an old system that needs improvement, the latter case is an efficient system that still requires information about possible externalities. Furthermore, due to authorities' lack of strategy, national energy associations and offices aim to modernize district heating using their limited funds instead of requiring consumers to offer a minimal contribution. Due to the lack of information, people are not aware about heating modernization alternatives. As a consequence, they prefer not to cooperate but to make an individual rational decision, which, unfortunately, might be irrational at the social level as the methodological part aims to test.

3.3 The Hungarian heating systems

The case of Hungary will be described within this framework in order to emphasize the main practices that can be considered as a model for Romania. Hungary, in contrast with Romania, has adopted a different approach regarding heating systems. While in Romania people prefer disconnecting from district heating systems and buy individual boilers, in Hungary, the demand for district heating is increasing although the tariffs have been raised in

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[94] *Ibid.*, p. 105;
[95] *Ibid.*, pp.217-218;

order to cover the prices of modernization.[96] In addition, legislation in some Hungarian counties requires that a large number of households in each utility remain publicly managed.[97] However, although the district heating comprises over 300 individual systems, only about 650 000 households (17% of the total households) are connected to the centralized system, while around 26% of the households use apartment or building systems and 57% use individual room heaters.[98]

Hungary is the first transition country that has developed a law – the Act on District Heat Supply – related to the heating issue in 1998, while Romania is still preparing one.[99] Furthermore, this country is considered to be an example of good practices in regards to a stable district heating sector that requires minimal subsidies.[100]

To save energy, an important measure taken by Hungary is the introduction of mandatory metering in all buildings connected to district systems, raising customers' awareness in regards with energy saving and making strategic decisions that are environmentally friendly.[101] Thus, Hungary can be considered a model regarding the use of cogeneration in the district heating sector as a guarantee for long term climate protection.[102] Furthermore, the quantity of hot water consumed has decreased since 1999 due to the improved behavior of people and to compulsory metering mechanism.[103] Besides, Hungary applies a "step-by-step" mechanism of modernization that implies renewing networks and

[96] International Energy Agency, "Coming in from the Cold. Improving District Heating Policy in Transition Economies", OECD/IEA, 2004, pp. 59-66;
[97] *Ibid.*, p. 183;
[98] Export Council for Energy Efficiency, "The Market for Energy Efficiency in Hungary", Available at http://www.ecee.org/pubs/hungary.htm, (accessed 8 May 2007);
[99] International Energy Agency, "Coming in from the Cold. Improving District Heating Policy in Transition Economies", OECD/IEA, 2004, p. 30;
[100] *Ibid.*, p. 48;
[101] *Ibid.*, p. 94;
[102] Sigmond Gyorgy, Association of Hungarian District Heating Enterprises, The case of Hungary in *District Heat in Europe. Country by Country/ 2003 Survey*, Published by EUROHEAT & POWER, The International Association for Combined Heat and Power, District Heating and District Cooling, Belgium 2003, p.181;
[103] *Ibid.*, pp.185-186;

building new pipelines for new consumers.[104] In addition, Hungary is one example in which large amounts of money (1.7 billion forint, meaning around 68.984.547 Euro[105]) have been allocated as a loan fund for energy related projects, the main criteria being energy savings.[106]

Regarding the way the heating sector is managed, local and national levels have different responsibilities. Thus, while national regulator focuses on big cogeneration plants (over 50 MW) and district heating networks, local level provides supply licenses for district heating facilities.[107]

In contrast with the case of Romania, the Hungarian heating system sector did not change considerably, remaining at 16% of the market in the housing sector[108]. This fact is due to high costs associated with the separation from district heating and with connection to an alternative heating system, as, for instance individual boilers.[109]

In sum, the Hungarian heating system differs from the Romanian one both in terms of rationality of consumption and of specific public policies developed. Although the main formal approach will be based on Romanian data – because of the comparison that must be made between district and individual heating systems, the Hungarian case can be developed as an example of best practice.

This chapter aimed to comprehensively describe the cases of Romania and Hungary from the point of view of heating systems. Furthermore, as the specialized literature emphasizes, while in Hungary the main issue is based on the modernization of district heating, Romania is characterized by a wide demand of individual boilers and by independence from the centralized system. The next chapter will focus on the difference

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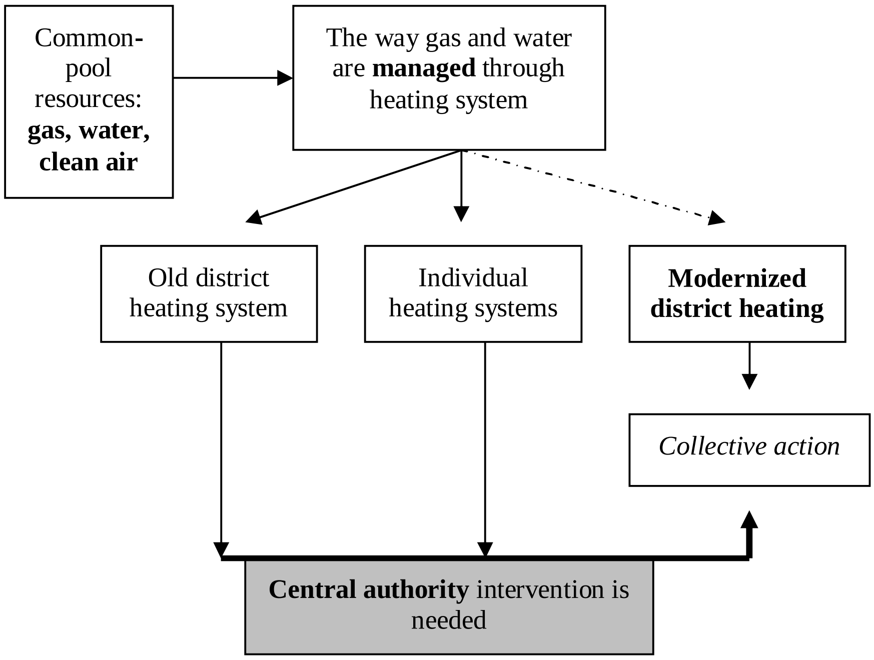
[104] *Ibid.*, p.180;
[105] The currency used is from Romanian National Bank, from 7 May 2007, 1 Euro = 246,4320 HUF, Available at http://www.bnr.ro/, (accessed 7 May, 2007);
[106] International Energy Agency, "Coming in from the Cold. Improving District Heating Policy in Transition Economies", OECD/IEA, 2004, p. 167;
[107] *Ibid.*, p. 106;
[108] Sigmond Gyorgy, op. cit., p.186;
[109] *Ibid.*, p.185;

between three types of heating systems mentioned above by approaching a formal method of computing net benefits in each case.

CHAPTER 4: A FORMAL APPROACH TO HEATING SYSTEMS

Based on the theoretical framework and on the *status quo* description, this chapter explicitly and formally makes the distinction between three types of heating systems - old district heating, individual heating system and modernized district heating. As the paper analyzes if by modernizing district heating systems, the social costs can be lower and the common-pool resources, as water, gas and clean air, better managed, the figure below graphically represents the main issue.

Figure no. 3 – The issue of heating system



Based on this figure, the main argument is the following. Heating systems use gas and water in order to produce warmth. Therefore, the way these two common-pool resources are managed should not be indifferent, in terms of efficiency. Thus, reality shows that, in the present, there exist at least two main possibilities of using gas and water within the heating systems framework: the old district heating systems and individual heating systems. However, the main focus of this paper is on the third alternative, namely the modernization of district heating. Although sooner or later this alternative is going to be put in practice, the questions that can be raised are when and how, or in what conditions.

In the case of Romania, the issue of disconnection from the district heating seems to become a very risky action, both from the point of view of heating agencies that cannot afford to survive with a small number of consumers and from the point of view of pollution generated by new mechanisms of producing heat (as, for instance, individual boilers). In addition, the modernization of district heating systems is not a cheap investment. On the contrary, as it will be shown in the next chapter, it implies big costs, which are almost entirely supported by heating agencies. However, based on the formal description that is going to be presented, this paper offers a solution to the aforementioned issues, namely, the contribution of all consumers to the modernization of district heating systems.

The transposition of reality into a game relies on mathematical computations of benefits for both choosing to purchase an individual heating system and for choosing to remain connected and to invest in district heating systems. Due to the fact that individual heating systems are not an alternative in the case of Hungary, the main focus will be on the case of Romania.

4.1 The functions of the game

Considering the background, this part of the paper aims to mathematically evaluate the hypothesis by constructing functions for each of the three analyzed heating situations: old district heating system (ODHS), individual heating system (IHS) and modernized district heating system (MDHS). The formal modeling aims both to simplify the issue of heating system by putting it in a mathematical format and to comprehensively understand the difference between different types of heating systems.

It can be logically deductible that if individuals have to choose among different types of heating systems and if they make rational decisions, they opt for the alternative that has the lowest cost and the highest quality. However, the main issue of this paper is to make both a parallel between district heating and individual one, and individual choice and social one. Furthermore, this paper tries to see if, in the case of heating systems, although there is rational choice at the individual level, the aggregated decision is not rational at the social level. In this respect, I aim to formally test if individual heating systems are more costly than the modernization of old heating systems. The role of the state in all this game is that of becoming conscious of the heating system issue, of informing people about the alternatives and payoffs and of creating incentives in such a way to persuade individuals to opt for the most social proper solution.

As the issue of heating system is a very complex one, the function for each case is going to contain variables, as, for instance, *comfort*, *control of the temperature*, the amount of *externalities* and *efficiency* of the system that cannot be quantified without specialized mechanisms, which are not the subject of this paper. However, they are going to be part of the functions due to their importance and they are going to be interpreted only from the point of view of their formal sign (positive or negative) as a cost or a benefit. In addition, these variables will reach a meaning and a theoretical value based on specialized literature described above.

Besides the four aforementioned parameters, the main quantifiable variables that are going to make an empirical difference between the three heating systems and that are going to be the main values within the game theoretical perspective are: the *investment* in the heating system, if it is the case, and an average of a *monthly maintenance costs*. In the case of modernized heating system, another variable will be introduced, namely the number of the subjects that is likely to invest in the modernization. The table below summarizes the used parameters.

Table no. 3 – The variables used in the formal modeling

Variables	Abbreviation
Investment in the heating system	*I*
Monthly maintenance cost	*MC*
Number of people investing	*N*
Comfort	*Com*
Control of the temperature	*Cont*
Externalities	*E*
Efficiency	*Ef*

It is important to note that all the variables will be considered at the household level. Furthermore, as it is not feasible to use information about the characteristics of all types of household, an average number will be considered for each variable. Thus, by summing up the main variables used, the general function of *heating systems* (HS) looks as it follows:

$$f(HS) = I + MC + Com + Cont + E + Ef$$

However, due to the fact that the signs of the included variables are not necessarily positive, a deeper discussion must be considered. Thus, the investment in the heating system, the monthly bill value and the externalities are coded as part of the costs, these two variables are going to be subtracted from the benefit in order to obtain the net benefit. Based on this statement, the general function is:

$$f(HS\_net\_benefit) = benefit - \cos t$$

In this case, as I have stated above, while the benefit is formed of comfort, control of the temperature and efficiency, the cost is composed of the investment, the monthly maintenance cost and externalities.

$$f(HS\_net\_benefit) = Com + Cont + Ef - (I + MC + E)$$

The following parts of this chapter are going to separately consider each case of heating system, by computing individual net benefits in all the three heating situations. Based on the formal modeling and on the available data, I try to give values for every heating system case in order to shape proper comparisons.

4.1.1 Old district heating system

In the case of Romanian old district heating system, the costs for the warmth depend on the dimensions of house and not on personal characteristics as income or comfort needed. For instance, a certain dimension of dwelling or a certain number of rooms corresponds to a certain quantity of gas and water provided, regardless of the amount of warmth needed. Therefore, there might be cases in which, although the members of the household do not need it, the level of warmth is very high due to the lack of control over the consumption. As a consequence, a large number of people, at least in the case of Romania, might pay for certain amount of goods - gas and water - they do not need and that can create even physical discomfort.

The discussion might go further in claiming that per-house income is an important aspect in the issue of heating systems. For instance, low-income families might have to give up on certain goods (such as food) in order to be able to pay something they do not need, or might prefer not paying at all. Considering the above case, connection to a different type of heating system might not be a feasible solution due to the investments implied. Thus, it is not only that the poorest social category does not have a proper income, but it seems it does not have the possibility to improve its situation either. This is a case of Pareto social sub-optimality, in which some players are worse off due to their choice lack of opportunity.

In sum, within an old centralized heating system, although there is the comfort of not being confronted with individual maintenance issues, power efficiency might decrease due to the wastages and to the lack of control over the quality and quantity of consumption. While, on the one hand, poor people cannot afford to invest in other types of heating systems or, if they invest, the products are qualitatively low, on the other hand, middle or high class people usually can afford the disconnection from the old district heating systems. It seems to be a socially unfair situation in which approximately equal opportunities are not possible and in which those that do not have resources are expected to pay more than the others.

Old district heating refers to the centralized systems that, at least in the case of Romania are not necessarily efficient. The monthly costs are very high and the members of the households do not have any control over the amount of consumption or of the temperature during the year because they do not have meters. The only variable that differentiates the amount of money people must pay is the number of rooms or the dimensions of the apartment.

The function for the old heating system comprises all the above-mentioned variables. The exception is the investment cost, which is zero in this case.

$$f(ODHS) = MB_1 + Ef_1 + Com_1 + Con_1 + E_1$$

I will consider the value of “control” variable as null because individuals do not have instruments in order to control the amount of warmth they receive. There might exist cases in which there is lack of comfort due to being too cold or too warm. The efficiency of consumption might be under question both due to the lack of comfort and to the wasted energy related to transportation, and thus, can be considered as a cost or as a null variable. In this case, specialized literature claims that the efficiency of centralized systems does not go beyond 70% because both of the annual revisions – when there are accidental cuts in the water and warmth provision – and of the wastes in the system due to the oldness– more than 50 years of functioning without radical improvements.[110] In addition, centralized system is characterized by the dependence on the neighbors. Thus, if the payments that are not done on

[110] APICT – The Association of Producer and Importers of Heating System (Asociatia producatorilor si importatorilor de centrale termice), Individual Heating System – Study Case, Available at http://www.apict.info/statistici.htm, (accessed 6 May 2007);

time might affect all the households in the building due to temporary breaking offs of the water and warmth provided.[111] This paper only takes into account externalities as negative effects.

The net benefit in the case of old district heating systems is the following:

$$f(ODHS\_net\_benefit) = -(MC_1 + E_1)$$

The variables considered in this case are the monthly maintenance bill and externalities, which, at the same time, are the costs of the household.

Due to the fact that there are no exact official data on the present monthly costs of a household that is connected to an old district heating, I will use estimations. Therefore, as unofficial data sustain, for an average number of family members and for an average household, a family connected to the centralized system paid in 2004 around 1.200 RON per year, which means around 100 RON monthly.[112] It means approximately 30,19 Euro[113].

The net benefit in the case of old district, although it is more of a cost, is the following:

$$f(ODHS\_net\_benefit) = -(30{,}19 + E_1)$$

Although the monthly financial cost per household seems not to be that high, the benefit of the system is minimal due to the lack of comfort, control and efficiency. However, the situation of old district heating systems is not an alternative anymore due to further modernization plans that already exist at the Romanian level.

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[111] *Ibid.*;
[112] "*Installations Technique*" Magazine, (Revista "Tehnica Instalatiilor"), Available at http://www.tehnicainstalatiilor.ro/articole/images/nr_13/82_84.pdf, (accessed 15 May 2005);
[113] The currency used is from Romanian National Bank, from 7 May 2007, 1 Euro = 3,3118 RON, Available at http://www.bnr.ro/, (accessed 7 May, 2007);

4.1.2 Individual heating system

Individual heating systems case is the case in which the state allows individual boilers' market to develop. This situation is a marginal propensity case in which people pay exactly the amount of resources they have consumed. In this case, there are no fixed costs involved beside the investment costs in the heating system. Unlike the above described case, individual characteristics, as the comfort needed in terms of temperature and control, are more valued. However, as every heating mechanism, this system has its shortcoming.

First, there might be the problem of interdependence. Due to the fact that within a building, common pipes are usually cut in the process of installing boilers, some householders might give in to the pressure of the neighbors and have to disconnect from the old system although they do not afford to invest in an individual heating system. Thus, in contrast to the case of Romania where the above description fits very well, as mentioned in the introduction of the paper, Hungary takes into consideration this situation by requiring each household's permission for disconnection within a building.

Those individuals that cannot afford to invest in individual boilers but, in a way, are forced to do that, might try to recover the investment by consuming the minimum amount of water and gas needed and by warming the minimum space used. Therefore, one might claim that an independent system can be associated with a diversification of consumption in accordance with income.

Second there is the problem of pollution. Although power efficiency and comfort are raised, and although the individual choice is rational in most of the cases, individual boilers, as described within the conceptual framework, are not inoffensive. In contrary, either they are not properly installed and collapse frequently or they provide neighborhood pollution.

Individual heating systems imply disconnection from the district heating system. Furthermore, in this case, individuals need to purchase the system by themselves. The function in absolute value for this case is the following:

$$f(IHS) = I_2 + MC_2 + Ef_2 + Com_2 + Con_2 + E_2$$

In the case of individual heating, consumers have control over the system and are independent of the neighborhood energy losses. Therefore, comfort and efficiency may be quantified as positive variables. Thus, the net benefit for the case of individual heating system is described in the following equation:

$$f(IHS\_net\_benefit) = Com_2 + Cont_2 + Ef_2 - (I_2 + MC_2 + E_2)$$

An estimated average of an investment on an individual heating system is around 766,36 Euros.[114] In addition, if the monthly cost is computed only for the consumption, without the investment, the estimated costs are around 62,6 RON[115], which means 18,9 Euros[116]. Based on these data, the equation is the following:

$$f(IHS\_net\_benefit) = Com_2 + Cont_2 + Ef_2 - (766{,}36 + 18{,}9 + E_2)$$

$$=> \; f(IHS\_net\_benefit) = Com_2 + Cont_2 + Ef_2 - (785{,}26 + E_2)$$

As expected, specialized companies that produce and distribute individual boilers are very much against the centralized heating systems. And if it is to take the information they provide as being accurate, the issue becomes even more delicate. It is believed that, although there are obstacles for those that want to disconnect from the centralized heating system and although there is the possibility of metering within this system, the problem of comfort cannot

114 "*Installations Technique*" Magazine, (Revista "Tehnica Instalatiilor"), Available at http://www.tehnicainstalatiilor.ro/articole/images/nr_13/82_84.pdf, (accessed 4 May 2005);
115 ASA Holding Romania – "Centralized Heating or Individual Heating System?", Available at http://www.euroheat.org/workgroup4/ASAPublicFolder_rom.pdf, (accessed 6 May 2007);
116 The currency used is from Romanian National Bank, from 7 May 2007, 1 Euro = 3,3118 RON, available at http://www.bnr.ro/, (accessed 7 May, 2007);

be solved due to the dependency of the consumer on the quality of the entire heating system.[117]

Having described the old centralized system, the individual boilers seem a very plausible alternative to it mainly if one takes into account the investment as a cost that can be damped during each month payments, for a year. In this case, if the overall monthly costs includes the investment in the boiler, the costs of material needed (e.g. pipes), the gas consume, the common neighborhood areas consume, the extra energy, cold water consume, individual connection (e.g. the documents needed – authorization, the project), technical bi-annual verification, the cost is around 165,83 RON[118], meaning 50,07 Euros[119]. Thus, the equation in the case of individual heating system is the following:

$$f(IHS\_net\_benefit) = Com_2 + Cont_2 + Ef_2 - (50{,}07 + E_2)$$

The difference between this type of computation and the above one, in which investment cost is entirely part of a single month costs, is significant. In addition, in comparison with the old district heating systems, although the financial cost is higher in the individual system case, the overall benefit is much higher by including comfort, control and efficiency components.

In contrast with the minimum comfort and maximum prices, individual system provides the possibility of controlling the amount of gas and water consumed and of self-managing them.[120] However, although the two above described systems have their benefits, the main emphasis of this paper is on testing if a third system is more efficient. Thus, the next part of the chapter formally describes the modernized heating systems.

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[117] APICT – The Association of Producer and Importers of Heating Systems (Asociatia producatorilor si importatorilor de centrale termice), Individual Heating System – Study Case, Available at http://www.apict.info/statistici.htm, (accessed 6 May 2007);
[118] *Ibid.*;
[119] The used is from Romanian National Bank, from 7 May 2007, 1 Euro = 3,3118 RON, Availablae at http://www.bnr.ro/, (accessed 7 May, 2007);
[120] APICT – The Association of Producer and Importers of Heating Systems (Asociatia producatorilor si importatorilor de centrale termice), Individual Heating System – Study Case, Available at http://www.apict.info/statistici.htm, (accessed 6 May 2007);

4.1.3 Modernized district heating system

Given the above discussion, although, at least in the case of Romania, heating agencies are the ones investing in the modernization of their equipment, this paper, proposes a hypothetical perspective in which consumers are the ones that must invest in the improvement of the district heating systems. This approach might serve as a policy application in the future that refers to both cost reduction of heating agencies and, thus, increased efficiency in the entire improvement of the system, and to a minimum investment of individuals in the renovation process.

The main debate of this paper is related to the difference between individual and modernized district heating systems. I claim that, in the long run, the latter is more beneficial than the former. Although it seems to be more effective to have an individual boiler, in most of the cases, this is because the real costs and benefits are not actually quantified. The main arguments that people might think about in favor of the individual heating system are the following: the negative experience with the old and inefficient centralized system, a better comfort and control of the temperature, and the belief that boilers are a cheaper option.[121] Therefore, a wider analysis that involves all possible important factors is needed.

Put it in other words, this paper aims to analyze if collective action is possible, from a game theoretical perspective, in order to lower social costs in terms of heating consumption. The bottom part of Figure no.3 represents the fact that, socially and individually speaking, an efficient modernization of district heating can emerge through collective action. As the largest part of the literature claims, collective action is most desirable but less possible, at least in

[121] The International Association for District Heating, District Cooling and Combined Heat and Power, "The Case for District Heating: 1000 Cities Can't be Wrong! A Guide for Policy and Decision Makers", p.17, Available at http://www.euroheat.org/ecoheatcool/project_3.htm, (accessed 7 May, 2007);

large communities. Voluntary action is not a proper solution one can rely on given the above described situation.[122] An improvement within a community can be properly done with the participation of a large number of people and not only of isolated ones.[123]

Besides information needed in order to increase the level of awareness regarding social effects of individual pollution, the state or public authorities in general might have to intervene and to provide regulations. New rules of the game might help in order to constrain people to cooperate. Although large communities may have a common interest, it does not mean that individuals will commonly act.[124] They either need to have an individual incentive in order to join the common action or there must be a compulsory action.[125]

In the case of heating systems, coercion seems to be the most plausible alternative given the size of the implied communities. Furthermore, as the literature claims social incentives or inter-individual pressure is successfully developed only in small groups in which face-to-face communication is possible.[126] Therefore, an outside actor, as the state, needs to intervene, first in order to inform the players of the heating game that there is a better option for each of them – that of investing in heating modernization -, and second in order to provide incentives and, if needed, coercion that can improve the social outcome.

The modernized district heating system resembles with the old district heating system in terms of centralized idea of functioning. However, the former can differ in a large number of respects from the latter, as for instance, the efficiency it provides, comfort and control individuals can have within this system. One of the most important variables that comes into discussion and that is different from the above two mentioned cases is the number of people

[122] Brian Barry and Russell Hardin (Eds.), *Rational Man and Irrational Society? An Introduction and Sourcebook* , (Beverly Hills/ London/ New Delhi: Sage Publications, 1982), p.20;
[123] *Ibid.*, p.23;
[124] The Economist on the back cover of Mancur Olson, *The Logic of Collective Action. Public Goods and the Theory of Groups*, (Cambridge: Harvard University Press, 1971);
[125] *Ibid.*;
[126] Mancur Olson, *The Logic of Collective Action. Public Goods and the Theory of Groups*, (Cambridge: Harvard University Press, 1971), p. 62;

investing in the modernization. Thus, the function of the modernized heating system is the following:

$$f(MDHS) = \frac{I_3}{N} + MC_3 + Ef_3 + Com_3 + Con_3 + E_3$$

As mentioned before, in this case, total cost, including the investment and the total monthly payments, depends on the number of people that contribute to the modernization. Thus, the more people cooperate in the game of modernization, the less money each of the individual has to pay. Furthermore, it is more likely to have social optimality and not under-investment. The net benefit in the case of modernized district heating is described by the following equation:

$$f(MDHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - (\frac{I_3}{N} + MC_3 + E_3)$$

Although the transition from the old heating systems to the modernized ones seems to be the initiative of the heating agencies, and although the cost of modernization is part of their contribution, a different perspective can be raised. As mentioned before, I argue that the individual monthly cost, including the investment in the modernization of the district heating, is lower than in the case of individual boilers. Since the net benefit in the modernization case depends on the number of households that invest, the previous statement seems to be valid in the situation in which a large number of people contribute to the renovation process. The perspective of individual contribution is a rational alternative from at least two points of view. First, each individual pays a minimum amount of money for a maximum efficiency and comfort. Second, heating agencies can afford to offer best quality in a shorter period of time and to a larger number of consumers.

Within this framework, the aspect of who is going to invest must be further discussed. Specifically, it is the issue of those consumers that have already invested in individual boilers or of those that have never been connected to a centralized system. The former ones are highly unlikely to give up on this investment and on the comfort they have and invest again in a system that did not provide them any benefit in the past and that is uncertain for them. They are even less likely to reconnect themselves to the modernized district heating system due to the fact that negative externalities of individual boilers not necessarily have a direct effect on them. In the latter situation, there are people connected to other types of heating systems, as, for instance, stoves with solid or liquid fuel or electric systems[127], who might be skeptical in approaching a new and unsure type of investment that implies interdependence on the system. However, although these situations are improbable, they are not impossible and some people that are not connected to the centralized systems might decide to invest in modernization.

Although it would be easy from the point of view of rational choice to predict individuals' action, it is not feasible to say that all consumers are going to choose the highest utility at the lowest price. As mentioned before, individuals that have already invested in individual boilers will probably desire first to recover their investment and not to invest again in another system. Although the investment costs are lower when the number of people investing is higher, it is unlikely that people that use household boilers to give up on this type of system that, in fact, brigs them a lot of benefits. I believe that a law designed in the present condition cannot compel the already disconnected people to reconnect to the district heating system, although this solution might be more beneficial. The number of people that is expected to invest represents mainly the individuals that are still connected to the old district system. This number might rise if those that have stoves can afford and desire to invest as well. In the following calculation, the number of households investing in the modernization coincides with the number of households connected to the centralized systems.

[127] APICT – The Association of Producer and Importers of Heating System (Asociatia producatorilor si importatorilor de centrale termice), Individual Heating System – Study Case, Available at http://www.apict.info/statistici.htm, (accessed 6 May 2007);

Considering the above discussion, based on the available data, the cost per household within the modernized system is computed in the following part. There will be considered two cases: the net benefit calculated before people actually started to disconnect and the net benefit in the present situation, in which a large part of the households have disconnected themselves.

First, I will estimate the investment costs per household, regarding the modernization of district heating systems, at the national level, *before people actually started to disconnect from the centralized systems*. Thus, considering that the number of households connected to the centralized systems in 1992 was 2.921.368[128], and that the number of households connected in 2007 is 1.082.628[129], we may estimate the percentage of households that are still connected to the centralized systems. Based on formal computation, 37% of the total number of households is nowadays still connected to district heating systems.

Due to the fact that data regarding the number of district heating systems is officially available only for Cluj county case – 107 systems[130], we need the above information in order to estimate the number of connected households in this area and, afterwards, to estimate the per household costs of investment in the modernization in 1992. Considering that in 2007, the number of households connected to the centralized system in Cluj is 60 000[131], and that it is estimated to represent around 37%, in 1992, we may estimate that the number of households connected to the centralized system in Cluj was around 162.162. Furthermore, having the number of district heating systems in Cluj, the number of people connected to them and the number connected to the centralized system at the national level, we may estimate that there

[128] Census Report 1992, Romania, Available at http://www.recensamant.ro/, (accessed 15 May 2007);
[129] National Authority of Public Service Settlement for Communal Households and Public Utility (Autoritatea Nationala de Reglementare pentru Serviciile Comunitare de Utilitate Publica), Available at http://www.anrsc.ro/index/servicii_energetice/starea_servicii_energetice_interes_local.htm, (accessed 15 May 2007);
[130] "Termoficare Heating Agency", Cluj-Napoca, Romania, information provided by the Manager Director of the company, 2006;
[131] "Termoficare Heating Agency", Cluj-Napoca, Romania, Available at www.ratcj.ro, (accessed 12 May 2007);

are around 1927 district heating systems in Romania. Thus, while the investment in the modernization in one district heating system is estimated to be around 750.000 Euro[132], the value of the total investment in modernization is estimated to be around 1.445.250.000 Euro. It means that, at a population of 2.921.368 households in 1992, the investment per household means 494,17 Euro. It is the case in which the entire system is renovated. Although there might be situations in which a single modernized district heating systems can generate energy for a larger area than an old district heating system. Thus, the amount of money that is required for renovation might be smaller, due to a lower number of district heating systems. However, due to lack of data, this situation cannot be transposed into a formal equation.

Having this information and estimating that the monthly maintenance cost in 1992 was approximately the same as in 2004 for those households connected to the centralized systems, meaning 30,19 Euro, as computed before, the net benefit per household in the modernized case is the following:

$$f(MDHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - (\frac{1.445.250.000}{2.921.368} + 30{,}19 + E_3)$$

$$=> f(MDHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - (494{,}17 + 30{,}19 + E_3)$$

$$=> f(MDHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - (524{,}36 + E_3)$$

Thus, the financial cost in the modernized district heating systems is 524,36 Euro. It means that if the persons that had invested in individual boilers had have the chance of investing in the modernization of centralized system from 1992 on, they would have had monthly lower financial costs and higher efficiency. However, since this situation is only a hypothetical one, and since it cannot be complied, an estimation of the investment costs in the modernized systems nowadays is needed.

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[132] "Termoficare Heating Agency", Cluj-Napoca, Romania, information provided by the Manager Director of the company, 2006;

Thus, second, I estimate *the investment costs per household in 2007 situation*. I use the same steps. I suppose that the number of district heating systems is relatively the same as in 1992. Therefore, having 1.082.628 households connected to the centralized system in 2007 and 1927 district heating systems, each system's modernization costing around 750.000 Euro, the estimated investment cost per household in the modernization of district heating is around 1334,95 Euro. The monthly maintenance bill is estimated to be the same as in the other case described above, namely 30,19 Euro. However, although there are no data available yet, this cost can significantly decrease after the modernization process and after the heating systems become more efficient. The net benefit in 2007 situation is described in the following equations:

$$f(MDHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - \left(\frac{1.445.250.000}{1.082.628} + 30{,}19 + E_3\right)$$

$$=> \ f(MDHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - (1334{,}95 + 30{,}19 + E_3)$$

$$=> \ f(MDHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - (1365{,}14 + E_3)$$

As it can be observed, the difference between 1992 and 2007 is due to the fact that 63% of households have disconnected during the last 15 years. This reality may mean that there is a problem and the centralized system confronts itself with a crisis. If the trend in disconnection continues the same way, without any external intervention, in a few years, centralized system might encounter significant existence issues. Therefore, modernization seems to be an urgent condition.

Although the modernized heating systems seem to offer higher benefits for a larger number of people, in contrast with individual systems, the main shortcoming that still remains is the interdependence on the entire system. By using meters, an important part of this problem is solved. However, a centralized system, although offering the efficiency and comfort needed, is very likely to remain a system that confronts itself with permanent technical problems related to the dimensions of the system.

In sum, this chapter aimed to review the issue of heating systems in a formal way. The formal modeling has been provided in all the three analyzed forms – old heating systems, individual heating systems and modernized heating systems, with more emphasis on the last one. The data that have been used, although not the most recent ones due to their lack of availability, have shown that the modernization of district heating can be the optimal alternative for each household, both in terms of financial costs and in terms of comfort and control. The main condition is that a sufficient number of individuals should invest in the modernization. Although the results of the formal model are based only on financial outcomes, referring to the costs of investment and to the monthly maintenance bill, the rest of the variables included in the model are emphasized by the specialized pieces of literature mentioned in this paper. The next chapter will further focus on the issue of heating systems by applying a game theoretical approach. The last aim of the paper is to completely test the hypothesis by bringing the idea of the game to the social level and to shape a policy recommendation.

CHAPTER 5: A GAME THEORETICAL APPROACH TO HEATING SYSTEMS

Considering the above formal approach, this chapter transposes the households' results, computed by using a cost-benefit formula, into an aggregate situation or a game in order to find the social equilibrium. If the transition from old district heating and maybe from individual heating systems to the modernized systems seems to be a desirable situation, the issues of collective action and of management of commons come into picture. Thus, state or local authorities may be the main actors that can intervene in order to inform about the new heating possibility, to establish the communicational network between consumers and between consumers and heating agencies, and to regulate the market by adopting a specialized legal framework.

5.1 Collective action within the game of heating systems

Although collective action is mainly associated with moral rather than logical concept, as Rapoport[133] claims, this paper analyzes the issue of collective action from the latter point of view. By using a game theoretical perspective of heating systems this chapter is going to focus on the way people from large communities can be determined to cooperate and to collectively act in order to improve both individual and social living conditions, from both financial and non-financial points of view.

It is claimed that the biggest payoffs come not from maintaining a game that is not proper anymore, but from changing the game and the rules of the game in a more beneficial

[133] Anatol Rapoport, "Prisoner's Dilemma – Recollections and Observations" in Brian Barry and Russell Hardin (Eds.), *Rational Man and Irrational Society? An Introduction and Sourcebook*, (Beverly Hills/ London/ New Delhi: Sage Publications, 1982), pp. 72-73;

way.[134] The present real game of heating system is a non-cooperative one, in which each individual aims to satisfy his/her own needs without taking into account his/her actions effects on the entire society. As the case of Romania is emphasizing, there are both individual and social issues that need to be solved by adopting a new game. Thus, the modernization of heating system can be a beneficial alternative both at individual and social levels. At the individual level, the amount of monthly paid money per household in the case of modernization can be lower than the in the case of old district heating system and than in the case of individual boilers, mainly if enough individuals contribute to the investment. At the social level, besides the fact that there is social equality, meaning that all those that invest need to pay exactly the amount of money associated to the amount of resources consumed, the system seems to promise a higher degree of efficiency in terms of the rapidity of the modernization process - if enough people invest, and a lower quantity of pollution.

Thus, the elements that can make the difference between an old district heating or an individual boiler and a modernized heating system, if the above condition is fulfilled, are the lower monthly costs in general, a higher efficiency for everybody regardless of the level of income, and a reduced amount of pollution. Furthermore, one of the possible civic benefits of the modernized alternative is the lesson of cooperation, of collective involvement for the case of the entire society. Although the state or local authorities are the main constraining actors in order to make people play the new game of cooperation, the main players that can decide the further development of the game are individuals.

Olson sets out two laws that are very much in accordance with the collective choice in general and with heating system issue in particular. While the first rule claims that there are situations in which, although individuals consider their own selfish interest, a collectively rational decision may emerge spontaneously, the second rule refers to the fact that in some

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[134] Adam M. Brandenburger and Barry J. Nalebuff, *Co-opetition*, (New York: Currency and Doubleday Publishing Group, 1996), p.69;

cases the first law does not apply without the intervention of a third part, regardless of the intelligence level of the actors implied.[135]

However, as a large part of the literature claims, collective rationality in big communities cannot be reached unless some external actors intervene and change the rules of the game. Collective rationality means that if all the players follow the rules of this collective situation, each player can be better off than in the situation in which he/she would have act only in accordance with selfish rationality.[136]

As stated before, there are two types of situations in which collective action is possible: the situation when there is small group of people that can communicate among themselves and the centralized situation in which there is coercion.[137] The case of heating system is the second situation. There is a very large community in which compulsory rules must be established by a third part. Thus, as literature claims, coercion increases the chances to reach collective contribution for a common good.

Besides the aforementioned discussion, the issue of the cost distribution needs to be brought into attention.[138] Although it is said that the outcome of collective action goes to all the members of the community and thus, that the free riding problem may occur[139], the present situation is not such a simple case. The main reason is that heating agencies must decide on the policy they will apply in order to control the investment. The control of the individuals that are connected to the modernized system can be done by installing meters for each household. From a logical point of view, all the households that are going to benefit from the modernization should pay for it. However, the main problematic issue is that the

[135] Marcur Olson, "Foreword" in Todd Sandler, *Collective Action. Theory and Applications*, (Michigan: The University of Michigan Press, 1992);
[136] Anatol Rapoport, op. cit., p.72;
[137] Lars Udehn, *The Limits of Public Choice. A Sociological Critique of the Economic Theory of Politics*, (London and New York: Routledge, 1996), p.210;
[138] *Ibid.*, p.212;
[139] Marcur Olson, "Foreword" in Todd Sandler, *Collective Action. Theory and Applications*, (Michigan: The University of Michigan Press, 1992);

costs for those that are still connected to the centralized system might be lower than for those that have already invested in individual boilers both due to the investments costs and to the network of pipelines that must be reinstalled in the latter case.

5.2 The game theoretical background

Considering the game theoretical approach as dealing with the issue of heating systems, three elements of the game need to be described. The ***context of the game*** refers to those external elements that can influence the output of the game regarding the game unfolding, the alternatives available, and costs and benefits to each of the actor. Considering that the main goal of the paper is to find evidence that a better coordination of collective choice decreases individual costs in the problem of central heating systems, the context can be describe as follows.

A significant percentage of people have individually decided to give up the old and inefficient centralized system and purchase personal heating system. At a first look, this might not be a problem. It may be claimed that every individual has calculated his/her own benefit from choosing one of the two alternatives - remaining connected at the district heating system or purchasing individual central heating system. From the point of view of economic benefits, at least in the short run, he/she has tended to choose the second one. This happened mainly because, at that time, they did not know that they have a viable alternative and thus, long-term implications cannot have been measured.

The main solution regarding the social sub-optimality situation is related to the institutional capacity to manage resources in a legal way, by prohibiting a certain kind of behavior and by removing the inefficient system. The social utility depends on how individuals manage to assume responsibilities in a context in which everything that is lost by one individual is lost by the entire community.

Even if most of the central heating systems are properly installed, they produce pollution. As mentioned before, a wrong position of smokestacks can influence neighborhood pollution and, in the long run, even global warming. Considering this problem, central authority can order a certain way of positioning and dimension of smokestacks by providing specialized regulations and, thus, preventing negative spill-over effects.

However, individuals opt for individual heating systems because they are more comfortable and cheaper in the short run. For example, in Romania, an average family with individual heating system has paid 9.3 million lei in 2003, which means 280,8 Euro[140], for hot water and warmth consumption, while families connected to the centralized system have paid around 17 million, meaning 513,3 Euro[141], for the same consumption.[142] Considering these aspects, the formal modeling and the game theoretical approach is offering the possibility of computing mainly the financial costs of the investment in heating system at the social level.

Related to the ***actors of the game***, the problem, as mentioned before, may arise regarding the size of the community in a cooperation and non-cooperation game. While cooperation at the community level seems to be improbable, in a non-cooperation game the number of the individuals does not generally change the strategic structure of the game.[143]

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140 The currency used is from Romanian National Bank, from 7 May 2007, 1 Euro = 3,3118 RON, Available at http://www.bnr.ro/, (accessed 7 May, 2007);
141 The currency used is from Romanian National Bank, from 7 May 2007, 1 Euro = 3,3118 RON, Available at http://www.bnr.ro/, (accessed 7 May, 2007);
142 Mihaela Balea, "The Bureaucracy Heats the Heating Systems Business" ("Birocratia loveste afacerile cu centrale termice"), "*Evenimentul Zilei*" Newspaper, 15 July 2004, Available at http://www.hotnews.ro/articol_2453-Birocratie-loveste-afacerile-cu-centrale-termice.htm, (accessed 12 February 2007);
143 Katharina Holzinger, "The Problems of Collective Action: A New Approach", Gemeinschaftsgüter: Recht, Politik und Ökonomie, Bonn, January 2003, p.18;

Therefore, a public authority is needed in order to establish the appropriate rules that lead to social preference aggregation.

Thus, it may be claimed that beside the individuals who are direct players, there are other actors that create rules and that define the market: public authority that can provide a legal system or the rules of the game and the entrepreneurs, in this case, the companies that produce and trade heating systems. The relation between these actors can be drawn, at the theoretical level, as a linked one: the state creates the judicial framework in order to regulate the entrepreneurial activity, which, on its turn, provides services for the individual.

The ***strategies*** of a game refer to solutions that rational players choose in order to satisfy their needs or expectations. Regarding the problem of heating system, individuals have at least two alternatives: remaining connected to district heating system and investing in its modernization, or purchasing individual heating systems.

5.3 The game of heating systems

The entire perspective on heating systems described above will be developed within this part of the chapter as a Prisoner's Dilemma game. The story of this game is the following one.[144] There are two prisoners that are suspected of committing a crime. Due to the fact that there is not enough evidence for convicting one of them, the police bases its strategy on what one informs about the other. If both declare that the other one is guilty, both will be convicted to a minimum punishment. If both remain quite, the punishment will be harsher than in the previous case for both of them. If only one of them speaks, he/she will be freed and the other one will be convicted to a maximum punishment. In this game, the equilibrium is defection-defection, meaning that the players do not cooperate among them.

[144] Martin J. Osborne, *An Introduction to Game Theory*, (New York: Oxford University Press, 2004), pp.14-15;

Prisoner's Dilemma shows that individually rational strategies do not necessarily lead to social optimality. A one shot game will be developed, in which a decision already taken cannot be changed. Once one has invested in the modernization of district heating, one cannot disconnect oneself during the game. It is the same situation regarding the choice of purchasing individual boilers.

The figure below shows the game format, with the strategies and payoffs included. It is important to notice that this game comprises the payoffs for the modernization strategy computed with data, regarding the alternative of modernization, from 1992 situation. It means that this is a hypothetical situation, which is not possible anymore, although the equilibrium is very well defined in this case. However, I have decided to include this game within the empirical model in order to emphasize the individual and social importance of a high number of people investing in the modernization.

Table no. 4 – The Prisoner's Dilemma Game - the case of heating system issue (1992 data)

		Payer 2	
		Individual heating systems	**Modernized district heating**
Player 1	**Individual heating systems**	$Com_2 + Cont_2 + Ef_2 - (785{,}26 + E_2)$, $Com_2 + Cont_2 + Ef_2 - (785{,}26 + E_2)$	$Com_2 + Cont_2 + Ef_2 - (785{,}26 + E_2)$, $Com_3 + Cont_3 + Ef_3 - (524{,}36 + E_3)$
	Modernized district heating	$Com_3 + Cont_3 + Ef_3 - (524{,}36 + E_3)$, $Com_2 + Cont_2 + Ef_2 - (785{,}26 + E_2)$	$Com_3 + Cont_3 + Ef_3 - (524{,}36 + E_3)$, $Com_3 + Cont_3 + Ef_3 - (524{,}36 + E_3)$

Due to the fact that the modernization of district heating seems to be an irreversible issue, which will happen in any circumstances sooner or later, the game is only taking into account the perspectives of modernized heating and of individual boilers. As the graphical form of a game does not permit a more than two players game, I have reduced the entire society to the above game. However, after discussing the implications of this game, a discussion for the case of the entire community is needed.

There are two players that usually find themselves in the situation of not knowing what the other one is doing. However, this is not a classical Prisoner's dilemma situation in which the players cannot communicate. Individuals who know each other or who live in neighborhood might have the chance to communicate among themselves. The main possible strategies are either investing in individual heating systems or investing in the modernization of old district heating. As the players can communicate, the decision is not necessarily a simultaneous one, but a decision that must be taken in a limited time.

As it can be observed in the above table and as the idea of game stresses, three situations can be illustrated. First, if none of the players invest in the modernization of the district heating but in the individual boilers, both players and the entire society has negative benefits from that. The aim of the game is that of establishing Nash equilibrium, a situation in which nobody has any incentive to change their state or the chosen strategy. Thus, as long as the state does not provide incentives in order to induce the decision of choosing the alternative that is both individual and socially desirable, this equilibrium cannot be reached.

Second, if one of the payers chooses to purchase an individual boiler and the other one chooses to invest in the modernization of district heating, which is the most probable situation that can happen in the real life, the costs of the latter individual depends on the decision of the former. In an n-player game, the amount of the investment in the modernization of the district system constantly depends on the number of the people who choose the individual alternative. As stated before, as the number of people investing in the modernization increases, the individual cost decreases.

Finally, in a two-person game, if both actors choose to invest in the modernization of the system, they can reach a Nash equilibrium that is Pareto optimal as well. Although in large communities this is not a possible situation, a desirable situation is that the majority of people play the modernized alternative.

Due to the fact that the above description is based on data for 1992 situation, a situation that cannot be reached anymore – in which people had not yet started to disconnect from the centralized systems, a more updated structure of the game needs to be developed. Thus, the game bellow uses the number of people that are still connected to the centralized heating system from 2007.

Table no. 5 – The Prisoner's Dilemma Game - the case of heating system issue (2007 data)

		Player 2	
		Individual heating systems	**Modernized district heating**
Player 1	**Individual heating systems**	$Com_2 + Cont_2 + Ef_2 - (785{,}26 + E_2)$, $Com_2 + Cont_2 + Ef_2 - (785{,}26 + E_2)$	$Com_2 + Cont_2 + Ef_2 - (785{,}26 + E_2)$, $Com_3 + Cont_3 + Ef_3 - (1365{,}14 + E_3)$
	Modernized district heating	$Com_3 + Cont_3 + Ef_3 - (1365{,}14 + E_3)$, $Com_2 + Cont_2 + Ef_2 - (785{,}26 + E_2)$	$Com_3 + Cont_3 + Ef_3 - (1365{,}14 + E_3)$, $Com_3 + Cont_3 + Ef_3 - (1365{,}14 + E_3)$

Regarding the efficiency of the systems, for which we have statistical data, the following comparison can be made. On the one hand, based on the specialized literature, while an old centralized heating system has an efficiency close to 35% but not higher than 70%[145], a modernized one can increase its efficiency up to 80-90%.[146] On the other hand, in the case of high technology that can be reached in the case of developed countries, the efficiency of individual boilers is evaluated to be around 86-90%.[147] However, studies that compare different types of individual boilers conclude that the level of efficiency may vary between 55% and 88%, depending on the technological characteristics.[148]

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[145] APICT – The Association of Producer and Importers of Heating System (Asociatia producatorilor si importatorilor de centrale termice), Individual Heating System – Study Case, Available at http://www.apict.info/statistici.htm, (accessed 6 May 2007);

[146] Dimtcho Gueorguiev Linkov, "Energy Efficiency of Space Heating in District Heated Buildings in Bulgaria", MA Thesis submitted to the Department of Environmental Studies, Central European University, Budapest, August 1998, p.7;

[147] The A to Z of Building, "Boiler Efficiency – The Legislation and Compliance", 29 September 2005, Available at http://www.azobuild.com/news.asp?newsID=1627, (accessed 30 May, 2007);

[148] DEFRA – Department for Environmental Food and Rural Affaires – Boiler Efficiency Database, Available at http://www.sedbuk.com/cgi-local/dynamicv.cgi?page=boiler8, (accessed 30 May 2007);

Thus, in the present situation, the game shows that at almost equal comfort, control and efficiency, the optimal solution for both players is choosing not to cooperate, meaning to invest in individual heating systems. The financial payoffs seem to be much lower in the case of modernization. However, based on specialized studies, a modernized district heating seems to offer at least the same benefits as household systems at the individual level, but much higher benefits at the social level in terms of pollution and efficiency.

Considering this situation, and knowing that in n-player game the spontaneous collective decision is unlikely to appear, the state seems to be needed to intervene at the level of the game to change rules and design new regulations. Put it in a different way, if the alternative of modernization of heating systems is really the best individual and social solution, the main condition for the modernization of heating systems to be less expensive than the investment in individual boilers is to have a high enough number of households investing in the former as the monthly costs to be the lowest possible. The following equations are formally explaining this statement and computing the minimal number of households needed.

As described before, the net benefit (nb) per household within *individual system* case can be noted as

$$nb(IHS) = b_2 - c_2 - E_2,$$

where $b_2 = Com_2 + Cont_2 + Ef_2$ is the benefit implied, E_2 refers to externalities (pollution)[149], and $c_2 = I_2 + MC_2$ is the quantifiable cost composed of investment and monthly bill. If this equation is considered for the entire community, with N households, we have the following form:

$$N \cdot nb(IHS) = N \cdot (b_2 - c_2 - E_2) = N \cdot x,$$

[149] In this part of the paper, externalities, for both heating systems analyzed, are being treated separately from the total cost, due to the fact that only the investment and the monthly maintenance costs can be quantified;

where x is the net benefit from the individual system.

In the same perspective, the net benefit equation for the *modernized district heating* is the following:

$$nb(MDHS) = b_3 - c_3 - E_3,$$

where, $b_3 = Com_3 + Cont_3 + Ef_3$ is the benefit implied, E_3 is the externality produced by the system, and $c_3 = \frac{I_3}{N} + MC_3$ is the quantifiable cost which include in the investment the number of households that contribute to the modernization process. In the case of N-player game, the equation is the following:

$$N \cdot nb(MDHS) = N \cdot (b_3 - c_3 - E_3) = N \cdot y - I_3,$$

where y is the net benefit from the modernization and I_3 is the value of investment in the modernization.

When talking about collective action the question is not only if an alternative or a decision is rational, but *when* or in what conditions this decision is rational.[150] Thus, having the two equations for the two heating cases, the main condition for the consumers to choose the modernization strategy is $N \cdot x < N \cdot y - I_3$, which means that the social benefit in the case of individual heating systems is lower than the social benefit in the case of modernized district heating systems. Considering this instance and the fact that collective action must be coordinated by an external actor, the state need to create that condition in which the number of the individuals that invest in the modernization to be higher than $\frac{I_3}{y - x}$. In numerical terms, it means that, if the total investment in the system is around, 1.445.250.000 Euro, as stated before, N must have a value above 5.539.478 individuals, which means an average of 1.846.492 households, if one household has an average of three members. This is the case in

[150] Gerald Marwell and Pamela Oliver, *The Critical Mass in Collective Action. A Micro-Social Theory*, (Cambridge: Cambridge University Press, 1993), p.9;

which data regarding the number of people investing in modernization are from 1992. The result is based on the following equation:

$$N > \frac{I_3}{y-x} \Rightarrow N > \frac{1.445.250.000}{Com_3 + Cont_3 + Ef_3 - 524{,}36 - E_3 - (Com_2 + Cont_2 + Ef_2 - 785{,}26 - E_2)}$$

If we assume that the comfort, the control over the temperature, the efficiency of the system and the externalities are similar in the two cases (modernized systems and individual systems), at least in the short run, the equation transforms into:

$$N > \frac{1.445.250.000}{-524{,}36 + 785{,}26} \Rightarrow N > \frac{1.445.250.000}{260{,}9} \Rightarrow N > 5.539.478$$

It means that, in order not to have a classical situation of Prisoner's dilemma in which players prefer not to cooperate, the number of households that must invest in the modernization need to be around 1.846.492 households - which is with 763.864 more than the actual number of households connected to the centralized system, of the total 8.107.114[151] estimated to exist in 2002 and considering that a household has, in average, three family members. Thus, not only that state regulations must apply to all the households that still use district systems, but it must take into consideration a strategy in order to convince people that are not connected to the centralize system to reconnect or to connect themselves. This adjustment of the number of families investing in modernization is needed in order to reach the optimal social situation and to switch from a defection game to a cooperative one.

[151] National Institute of Statistics, Census Report 2002, Romania, Available at http://www.insse.ro/cms/files/RPL2002INS/vol3/titluriv3.htm, (accessed 15 May 2007);

Using the data from the 2007 case in which a smaller number of households are connected to the centralized system, the equation becomes the following:

$$N > \frac{I_3}{y-x} \Rightarrow N > \frac{1.445.250.000}{Com_3 + Cont_3 + Ef_3 - 1365{,}14 - E_3 - (Com_2 + Cont_2 + Ef_2 - 785{,}26 - E_2)}$$

$$N > \frac{1.445.250.000}{-1365{,}14 + 785{,}26} \Rightarrow N > \frac{1.445.250.000}{579{,}88} \Rightarrow N > 2.492.326$$

It means that, at an average of three persons per household, the number of households that must invest in the modernization in order to have a socially optimal situation is 830.775. This number shows that less than the number of households that are still connected to the centralized system need to invest in modernization in order to have social optimality. As in the above case, in the present situation, only the households that are connected to the centralized systems have been included in the computations. However, since one of the main aims in the case of modernization is that household pay the smallest amount of money possible, the number of investors needs to be as high as possible.

The above described situation is the problem of "critical mass"[152] that must contribute to collective action, in this case, the investment in the modernization of the district heating systems, in order to accomplish the state of social optimality. As voluntary participation in collective action is not necessarily a very likely situation, the state is supposed to intervene in order to establish social optimality. By first informing people about their options, about the costs and benefits for each case and, second, by constraining enough people to choose the best social situation, state needs to change the Prisoner's Dilemma into a cooperation game.

This paper has tried to apply a very realistic approach. However, it has not taken into account two important aspects that can much easier lead to the situation of cooperation, by

[152] Gerald Marwell and Pamela Oliver, op. cit., p.1;

making the payoff for modernization of heating systems even higher for each household. These aspects are the European funds that are directed for the improvement of energetic system – around 17 million Euros for 2007 energetic projects[153], and the price rise of gas that can significantly increase the monthly maintenance bills with almost 53%, for those that use individual heating systems[154]. Therefore, although not significantly, having a European Union contribution, the amount of money per household can decrease with around 15 Euro, as it can be seen in the following computations (1349,43 Euro and not 1365,14 Euro as in 2007 case described above).

$$f(MHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - (\frac{1.428.250.000}{1.082.628} + 30{,}19 + E_3)$$

$$=> f(MHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - (1319{,}24 + 30{,}19 + E_3)$$

$$=> f(MHS\_net\_benefit) = Com_3 + Cont_3 + Ef_3 - (1349{,}43 + E_3)$$

In the case of a more expensive gas, the estimations are not relevant because nobody knows how many families that have individual heating systems are going to give up on these systems due to higher prices. However, it can be predicted that with a permanent high price of the gas, people might be more skeptical in purchasing individual heating systems.

This chapter has approached the issue of heating system from the point of view of game theoretical modeling. After the computation of the payoffs for both centralized and individual heating systems, I have showed, by using a Prisoner's Dilemma game that the analyzed issue needs to include cooperative players in order to reach social optimality. The simplified format of the game has used two players that can choose between two alternatives – purchasing in individual systems or investing in the modernization of centralized systems.

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[153] Gabriel Botezatu, "In 2007, only 17 million Euro European Funds for Energetic Projects", "*Curierul National*" Newspaper, 23 January 2007, Available at http://www.eafacere.ro/art_item.asp?artCatID=2&artID=4119, (accessed 20 May 2007);

[154] Mihai Nicut, "Gas Massive Endearment", ("Scumpire masiva la gaz"), "*Cotidianul*" Newspaper, 16 May 2007, Available at http://www.hotnews.ro/articol_72714-Scumpire-masiva-la-gaz.htm, (accessed 17 May 2007);

In the hypothetical case of 1992, the equilibrium of the game could have been reached without external intervention in the case of rational players. However, in the present situation, in which a smaller number of households are still connected to the centralized system, the equilibrium of the game is not socially optimal. Therefore state is required to enter the game by transforming it from a classical Prisoner's Dilemma into a cooperation-cooperation game. When the game is considered for the entire society, the duty of the state seems to be that of including enough people in the game in such a way that the decision of modernization to be efficient to both individual and social level.

CHAPTER 6: CONCLUSIONS AND POLICY RECOMMENDATION

Heating systems in Romania has caused heavy problem due to high rates of disconnection from centralized systems and to the level of pollution generated by individual heating boilers. This paper has analyzed, from a formal perspective, if purchasing individual heating systems or investing in the modernization of district systems induces a more effective management of common-pool resources and provides greater benefits at both individual and social level. Although the paper started as a comparative approach between Romania and Hungary, the main focus is on the former due to its rare and problematic situation. However, policy recommendations are mainly based on the example of the latter.

As the specialized literature emphasizes, the modernization of district heating in general seems to be desirable due to numerous disadvantages of the old systems, for instance, lack of efficiency, high prices, and wasted energy. Thus, by the renovation of old systems, common-pool resources, as water and gas, can be better managed at both the individual and social level. In this framework, although the investment in the modernization implies large amount of financial resources, the improvement of heating systems seems to be irreversible. Due to the fact that heating agencies may not afford to invest in the modernization of all district heating systems at the same time, this paper proposes a more efficient alternative that can improve both agencies' and individuals' conditions. The solution is that state directing people's action towards collective contribution in the investment process. Thus, on the one hand, agencies pay less and can concentrate on the mechanisms needed for modernization. On the other hand, individuals pay a small amount of money in order to improve their heating conditions in the long run.

Some of the problems that can be mentioned in relation to the heating systems issue are the following. First, in the game of modernization, in order to have individual and social optimality, a high number of people must contribute. As shown in the empirical part, in the

1992 hypothetical case, this number is higher than the number of households still connected to centralized systems. It means that, for the investment to be individually minimal and socially optimal, a number of people that have household heating systems or that use stoves or any other type of heating system should choose the modernization strategy. This situation is not necessarily improbable, but it might raise certain obstacles. For instance, while in the case of household that use personal boilers an investment has already been made, in the case of stoves, a network of pipes must be entirely developed for certain areas.

In the case of 2007 situation, due to the fact that the cost has been computed for a smaller number of possible investors, the cost per household seems to be higher. However, this cost can be significantly reduced if additional people invest in the modernization. An important note is that in both 1992 and 2007 cases, the number of households investing in the renovation process coincides with the number of households connected to district heating systems.

Second, at the social level, the sooner the investment is made the better, due to other possible disconnections that can emerge meanwhile. If the modernization is done in proper conditions and in a minimum amount of time, many people may benefit earlier from it. While each household connected to the modernized systems will have control over their consumption and over the thermal comfort they need, the entire society will benefit from the modernization by reducing the wastes of energy and by increasing the efficiency of the entire system. Furthermore, if a large number of people that used to have individual heating boilers decide to give up on them and to connect to the modernized systems, the amount of pollution coming from the inadequate position of personal smokestacks might be reduced for the entire neighbourhood.

However, in the social situation, voluntary cooperation seems not to be possible at the community level. Therefore, an external actor, as for instance, the state or public authorities, need to be introduced within the game and change the classical defection-defection equilibrium into a cooperation-cooperation one. The state needs to provide sufficient incentives and regulations in order to create a collective action situation and in order to better manage the common-pool resources.

Being an issue of limited common-pool resources (e.g. gas, water, and clean air) and of a large community of consumers, external incentives, as I have said before, are needed in order to create a situation of social efficiency. In the case of large communities, as the situation of heating systems, the most appropriate incentive seems to be that of developing regulations. Although it is believed that by purchasing individual heating systems people make a rational decision, at the social level these decisions are likely to be sub-optimal. At least three aspects, based on the specialized literature and on empirical evidence, can be mentioned in order to sustain this statement. First, there is the issue of pollution. The improper installation of the individual systems' smokestacks, the lack of technical revisions or the poor quality of second hand mechanisms seems to significantly increase both the risk of explosions and of neighborhood pollution.

Second, although both individual boilers and modernized district heating systems are characterized by high degrees of comfort and control, in the long run, and at the social level, the two systems are very likely to differentiate themselves in terms of efficiency. Being connected to a specialized agency that can always intervene and repair the possible damage and that can improve the entire system without producing negative consequences for the consumers, may induce a higher level of efficiency and control.

Third, as the empirical part of the paper shows, if the number of households investing in the modernization of district heating systems is high enough, financial monthly costs per family decrease significantly. Furthermore, today, the prices the individual heating systems might even outrun the cost of being connected to the old centralized systems due to the fact that the gas costs have increased significantly in the later period.[155] It is also important to notice that while the increase of the monthly costs within individual boilers' situation is very likely due to gas price rise, a relatively large amount of money is coming from European Union funds for the improvement of energy mechanisms. Thus, the alternative of modernization seems to be feasible.

By using a cost-benefit model and by developing a Prisoner's Dilemma situation, I have shown that, in the case of Romania, individuals' investments in the modernization of district heating is an efficient alternative both for consumers and for heating agencies. While the former benefit from high levels of interior comfort at minimal costs, the latter delegate the investment costs to consumers and focus more on the efficiency they provide.

Although rational choice does not fully explain people's behavior, I believe that in the case of heating systems, it is the most appropriate theory to use. Having a system that is defined by costs and benefits and having individuals that have limited amounts of money, it proves to be useful to apply a rational choice model. The story of heating systems is in fact a very simple one, in which it is rational to choose the modernization of heating systems as the best solution from both financial and efficiency perspectives, and the empirical analysis has given this reality a formal sense.

In sum, as the data show, the hypothesis of this paper is sustained by the empirical evidence. The investment in the modernization of district heating systems seems to be a more efficient solution than purchasing individual boilers. At least two conditions must be accomplished in this case. First, the state must create incentives for a better management of common-pool resources, must inform the society with regards to the options they have and to best strategies, and must design proper regulations in order to constrain people to choose the

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[155] Iulian Enache, Mihai Nicut, "The War of Expensive Gas", ("Razboiul scumpirii gazelor"), "*Cotidianul*" Newspaper, November 2006, Available at http://www.cotidianul.ro/index.php?id=7730&art=19785&cHash=f8210dfee1, (accessed 13 May 2007);

socially optimal strategy. Second, enough households must play the collective game of modernization in order to increase optimality at both individual and social level.

Based on the empirical framework and on the example of Hungary, the final aim of the paper is making a policy recommendation. In the case of Hungary, as mentioned before, the monthly costs have been raised in order to cover the reconditioning process of district heating. In the empirical part of this paper, a similar strategy is adopted in computing the benefit. The general payoff, for both heating agencies and individuals, seems to be higher if every household contributes to the modernization. Therefore, the state should first raise the customers' awareness by informing them about costs (for instance, pollution) and benefits (for instance, energy savings) for each system and second, it should create regulations that can constrain consumers to choose the socially desired alternative. However, a total constraint in order to opt for centralized heating systems is not necessarily the most democratic and fair option. As in the case of Hungary, disconnection should still be an option. Individuals should still be able to choose the disconnection option but its costs should be significantly increased. A possible situation is that in which a household is disconnected only if all the people in the building desire the same thing or the financial costs of disconnection are high.

Although Romania has started the program of modernization, the total improvement by using cogeneration in the district heating sector seems to be the most appropriate alternative for guaranteeing climate protection. Due to the fact that modernization requires energy saving, a demand driven policy is needed. Thus, as part of the modernization process, the installation of meters in the households connected to the centralized systems is a solution for improving the temperature control issue.

In addition, I believe that a division of labor between central and local governments might help. While the former may be the regulator actor in regard with the general legislation, the latter can be the provider of the necessary information.

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