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Long-term Green Innovation Opportunities Within the Hungarian District Heating Sector Towards 2030

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Abstract: *Natural gas is still the primary input of the Hungarian heating and cooling systems, therefore it still makes most of the overheads. One of the main obstacles of a competitive district heating system is the public opinion which still considers this service more expensive than the traditional heating forms. According to the absolute numbers this assumption might be valid but from a more accurate economic perspective, heat production has more aspects to stress. Most people forget about the simple fact that the maintenance costs of natural gas based systems are rather outsourced to the consumer than in the case of district heating. Furthermore, the uneven rate of the fixed and variable costs of this technology does not prove to be optimal for service developments. Investigating the future tendencies highlight that encouraging the efficiency improvement of district heating and the spread of technological innovation in the sector does not belong to the top priorities. Still, avoiding this problem it could lead serious deadweight losses in the case of the heating sector.*

Keywords: *district heating, energy efficiency, renewable energy, climate policy*

1. INTRODUCTION

The explosive growth of Earth's population in recent decades, the increase of industrial production's volume, and the increasing interest in fossilized energy resources obviously show that the energy management based on sustainability became inevitable for today. The scarcity of fossilized energy resources suggests that the resources at hand have to be exploited to the best possible level using the given technological level, and to consider energetics policy measures which are mainly based on the usage of renewable energy resources [1, 2]. The input material of heating and cooling energy usage is mainly natural gas, and in Hungary, procuring it also makes up for most of the expenses and overheads [3]. The reason for this is that district-heating service uses natural gas as its decisive energy resource input. Hungary had 70% from its district-heating made up from natural gas already during the early 2000's. In 2009, the share of natural gas in consumption used for district-heating was 81% already, which also greatly influences the competitiveness of the district-heating service's costs.

Also, if its price is high, it negatively influences its market position as well, when compared to personalized and central gas heating solutions. In 2009, the share of coal and crude oil together was only 7%, while this value was over 10% in 2005. The remaining 12% is split between renewable resources, smaller part of which is waste, and technological heat or by-product [4]. If we evaluate the data from 2012, we can see that natural gas is still the biggest shareholder, but also notice that the share of alternative energy resources is slowly on the rise (Figure 1).

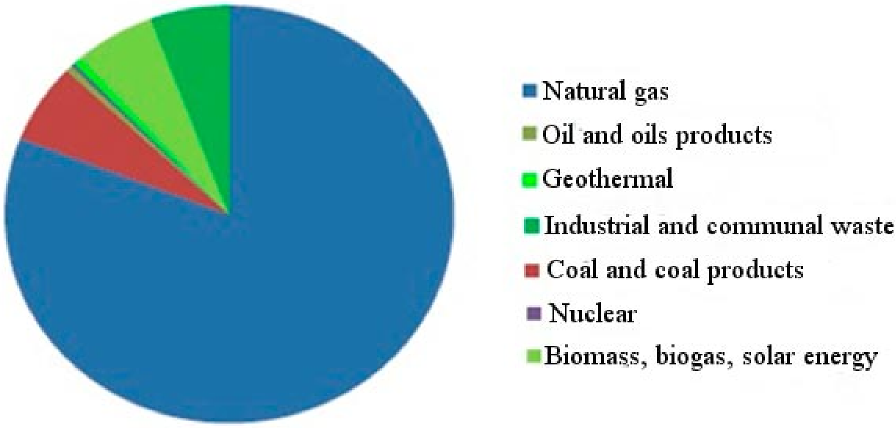

Figure 1. Structure of fuels produced for district-heating in 2012 Source: [5]

We can increase the share of renewable energy resources in district-heating production for 2020 to approximately 24%, while until 2030, this share may be increased to 32%, according to the "National Energy Strategy 2030". If we look at the changes in Budapest's fuel portfolio, we can expect the energetic usage of waste to increase its share until 2020 (Figure 2).

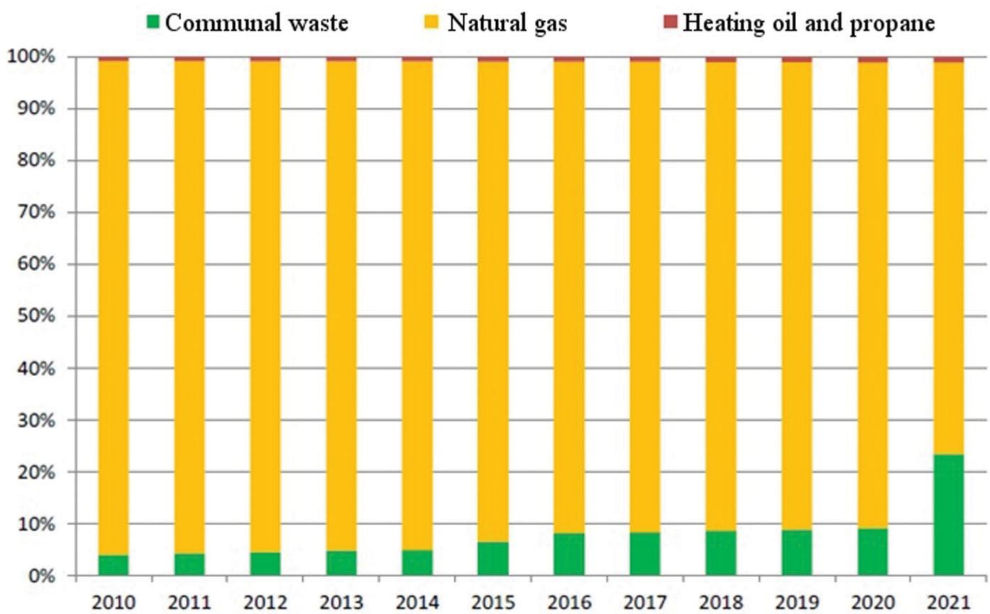

Figure 2. Budapest's fuel portfolio changes Source: [5]

Hungary generally supports the heat required for district-heating mainly from heating sources operated using gaseous fuels, f.e. cogeneration sources and furnaces.

Currently, there are not many renewable energy resources matching district-heating, the usage of low quality fuels is low, and the waste heat exploitation is barely noticeable, since the required machinery is not present. Currently, many of our district-heating systems are operating below the planned performance capacity, since many industrial and public facility consumers detached, which lead to the increase of losses by service unit in recent years.

Regulation elements cause significant effects on the heating energy sector, since it's a strategic sector. We can estimate that future effects decision-makers have on the sector remains significant, since if renewable energy resources will have to be used in greater volume, political and financial aid will be indispensable (Figure 3).

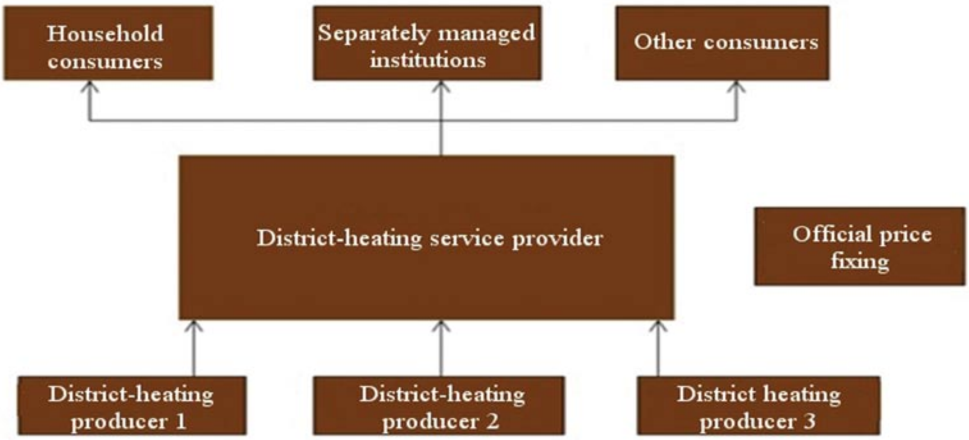

Figure 3. Structure of domestic heat production Source: [6]

The energy policy concept requires the following factors to be taken into consideration [7]:

1. Prognosis of estimated energy demand;
2. Energy resources the country has available;
3. Amount of domestic and foreign capital committable to the investments, which include the estimated future price range of various energy resources and the amount of interests important to payoff;
4. Current and expected technical development routes;
5. How assured energy supply is.

Nowadays, one of the main problems for a competitive district-heating service might be the fact that the cost of district-heating compared to gas (central) heating is perceived to be much higher by consumers.

The reasons for this can be found in the following:

• Ratio of fixed and variable costs is not optimal from the service development perspective;

• The fact that operation and maintenance costs of natural gas-based heating systems weight more on the consumers doesn't compute properly (these are not in the heating bills), compared to district-heating systems;

• The domestic district-heating systems operate with much too high cost levels, most notably the gas-tariff- and pricing-systems [6].

When designing district-heating offers, various measures have to be synchronised so that both the service providers and the consumers are interested in the modernisation. This may cause fossilized gases, or other traditional energy resources to be exchanged and that energy efficiency, and cost-efficiency through savings can be realised. The development programmes of the next period have to be synchronised in a way that not only the district-heating system is modernised, but the pipe systems and end user systems are also brought up to date, since the effectiveness parameters can only be optimised in this system. The increase of district-heating's quality has to increase for the sake of the sector's competitiveness, while the area district-heating services cover also has to increase. This requires the betterment of the service's quality, adequate cost levels have to be set, and making the district-heating more desirable for consumers via making cooling-heating services and cogeneration systems. The integration of local sources into the system is also required for the efficiency of the service.

2. MATERIAL AND METHODS

This study mainly concerns itself with the European Union's programming period, namely the interval between 2020 and 2030. Its focus is the evaluation of Hungary's heating sector from a climate policy perspective, during which we can determine development routes which can help the sector work in an environmentally friendly manner. For this, we first need to analyse the climate policy goal system of the European Union planned for 2030, which we can use to create a "best practice" to compare the sector's ideal mechanism to. To conduct the analysis, we chose the benchmarking method due to this, which is applicable to evaluating the long-term development concept of the heating sector, related to the future "low-carbon economy" goals. The benchmarking method is a level-comparison process, which can be used to analyse all time- and space- attributes of any sectors [8]. It's basis is a condition system made by ourselves, and indicators assigned to it, used for evaluating the future environment based on the present one. However, this requires a "baseline" system, which we compare the period after 2020 to. This is what we use the 2010-2020, identically lengthy period for. Its advantage is that not only the climate policy goal system is used until 2020, but regulations created to reach it as well (National Energy Strategy, National Building Energetics Strategy). Furthermore, since we've passed half this period already, we know the performance up until now as well. Therefore, the benchmarking methodology mainly aims to determine an optimal state of affairs, which we can compare our analysed systems to.

The framework of the analysis was supplied by the cornerstones of the European Union's climate policy, which are the following:

- Increasing the share renewable energy resources have in the sector,
- The increase of energy efficiency,
- The decrease of CO_2 emission quantity.

During the analysis, we evaluated the domestic heating sector's *technological, environmental and economic* dimensions through three main aspects, and assigned 3-3 indicators to all dimensions. The framework system we made can be seen in Tables 1, 2 and 3.

Dimensions	Code	Status indicators	Code	Performance indicators (defining the method of development)
	ASPECTS OF THE RATIO OF RENEWABLE ENERGY			
Technological	RS1	Specific analysis and general attributes of used energy mix	RP1	Changes in the usage of non-renewable energy resources, increase or decrease in the usage of fossilized energy resources in the analysed sector between 2020 and 2030.
	RS2	General quality and development options of used technical appliances and tools	RP2	Development possibilities of technical quality among the given economic conditions t
	RS3	Level and attributes of renewable energy resource usage	RP3	Possibility of using renewable energy resources in the sector, possibilities of increasing share in the sector
Environmental	RS4	Attributes of being part of the waste energetic recycling system	RP4	Evaluated by role in aiding renewable energy systems
	RS5	Results / connections of the benchmarking conducted on emission/immission values	RP5	Possibility of decreasing emission levels using renewable energy resources
	RS6	Tier/level of companies' environment management, the general sector attributes of environment management systems	RP6	Evaluating ISO 14 001 systems in the process
Financial	RS7	Is it a member of renewable, emission market through the usage of sector resources (CDM, JI, VER)	RP7	Evaluating activity (depiction of carbon financing)
	RS8	Intensity/activity of environment policy/climate policy regulations	RP8	Effect regulation has on production output
	RS9	Complexity of resource efficiency - labour market effects, effect on employment	RP9	Evaluation of workplace-creating effect, details of its significance

Table 1. Indicator group 1 of the heating sector benchmark analysis
Abbreviations: 'RS1 - 9:' status indicators of the ratio of renewable energy, according to dimensions; 'RP1 - 9:' performance indicators of the ratio of renewable energy, according to dimensions

Dimensions	Code	Status indicators	Code	Performance indicators (defining the method of development)
	ASPECTS FOR INCREASING ENERGY EFFICIENCY			
Technological	ES1	Share of fossilized energy resource usage in all consumption	EP1	Evaluating the quality of fossilized energy resource usage, using comparison to the EU's
	ES2	Possibility and level of energetic system relations	EP2	Connection to local and international systems for the optimal supply and cost reduction
	ES3	Possibility, tier/level of using clean tech solutions, possibility of introducing further low-carbon (GHG emission decreasing) technological solutions	EP3	Possibilities of implementing low-carbon technological solutions
Environmental	ES4	Possibility of implementing industrial ecology	EP4	Specifics of system attributes aiding circular processes
	ES5	Effect circular waste usage has on the efficiency of energy resource usage	EP5	Based on the energetic usage practice of waste
	ES6	Level of energetic losses	EP6	Level of measures taken to prevent losses
Financial	ES7	Cost-efficiency parameters of increasing energy efficiency	EP7	Cost-efficiency analysis based on general technological levels
	ES8	Usual costs of increasing eco-efficiency (combined efficiency of its service system)	EP8	Eco-efficiency analyses based on general sector attributes
	ES9	Importance of regulation elements in production processes	EP9	Effect regulation has on the improvement of technological quality

Table 2. Indicator group 2 of the heating sector benchmark analysis
Abbreviations: 'ES 1 - 9:' status indicators of the energy efficiency aspect, according to dimensions; 'EP 1 - 9:' performance indicators of the energy efficiency aspect, according to dimensions

The Tables show that our indicator system consists of *State indicators* and *Performance indicators* forming two distinct groups. The former is a static indicator, which marks an area often not definable via numbers. The state indicator's function is to determine points within the system, which may possibly have a significant effect on the future operations of the sector.

The performance indicator, contrary to the state indicator, can be considered an attribute which we are able to define using quantitative terms. This is how we can use them to get information on the actual workings of state indicators. As we've already talked about it, evaluating indicators wasn't only conducted for the 2020-2030 period, but for the 2010-2020 period as well, since it's required to serve as a basis for comparison.

Therefore, possible current anomalies can be corrected later. The 10 year periods also give an example on what problems may surface during long-term planning that affect the sector's inner workings. Already known tendencies give us reason to assume the process of decade-long planning has to be inspected every five years [9]. We compared the elements of the Hungarian general energetic planning, only related to buildings, to the climate goals defined for 2020 and 2030, following which we used professional estimation to determine if the heating sector is capable of reaching them. The indicators of Table 3 were determined to picture the level of externalities the system is amassing.

Dimensions	**Code**	**Status indicators**	**Code**	**Performance indicators (defining the method of development)**
	THE ASPECTS OF CO_2 REDUCTION LEVELS			
Technological	CS1	Intensity of GHG emission in light of technology	CP1	GHG emission based on evaluating possible technological solutions
	CS2	Possibility of introducing low-carbon technological solutions in the sector	CP2	Usage level of known low-carbon technological solutions
	CS3	Possibilities of introducing low-carbon technological solutions in the sector	CP3	Characteristics of general GHG emission in the area
Environmental	CS4	Environmental attributes of emitted greenhouse gases	CP4	Describing the environmental attributes of detrimental emissions, evaluating it from the possible measures' perspective
	CS5	Consequentiality of environmental regulations / norms, and thresholds	CP5	Does the regulation aid or limit the completion of environmental policy goals
	CS6	Environmental risk levels of emission rates	CP6	Attributes and quality of adaptation measures
Financial	CS7	Attributes / levels of GHG's market presence	CP7	Share all CO_2 emission has on all sectors under the jurisdiction of regulations
	CS8	General costs of avoiding one unit of CO_2 equivalent	CP8	Cost index of the CO_2 decrease in the evaluated sector
	CS9	Possibility of using CO_2 detachment and containment in the sector	CP9	Possibility of achievable CO_2 decrease using a CCS project in the sector on the EU level

Table 3. Indicator group 3 of the heating sector benchmark analysis
Abbreviations: 'CS 1 - 9:' status indicators of the aspect of reducing CO_2 emissions, according to dimensions; 'CP 1 - 9:' performance indicators of the aspect of reducing CO_2 emissions, according to dimensions

Interpretation of externalities in climate policy research

The term externality in its traditional economic meaning, refers to effects outside of the system, which are not, or only partially possible to define in monetary terms. Due to this, we have difficulties reacting to them among the market regulations [10]. During our analysis, we used a different interpretation, which states externalities are parts of an overall measurement system which determines the chance of success for development initiatives [11]. According to this interpretation, we consider all positive or negative economic, social, and mainly environmental elements to be externalities, which though have an effect on the end on development strategies, decision-makers don't take them into consideration. To map extern effects, we used market contradictions, and possible hindering or aiding factors of planned developments. This logical thought process results in that our evaluation system's goal is to determine how various indicators influence the sector in reaching climate policy goals. Based on this, the Tables' indicators seen above were assigned a value on a ((-2), (-1), (0), (1), (2)) scale, according to their performance. A negative value always refers to the fact that the indicator's effect causes underproduction in the system, and keeping the current state of affairs can't offer a way to reach climate goals. Contrary to this however, the positive value doesn't mean optimal performance. Since at this point, the system could possibly perform better based on the signs, however, current conditions don't make it possible for it to do so. Meaning we're seeing unused potentials. The optimal operation conditions are marked by the 0 value, where the current business (Business as Usual) is sufficient to reach goals, and there's no need to do anything else. If in the end, we summarised all externality amassments in all aspects, their sum gives us how the sector's renewable energy usage, energy efficiency, or CO_2 decrease differs from the best practice. The amassment of negative system attributes refers to a bad structure, which has to be changed as soon as possible, and investing more capital into the system is futile. The reason for this is that investments don't pay off later. However, in case positive externalities overgrow, focusing on these unused potentials, and making sure sufficient resources are allocated is advised.

2.1 Demonstrating the evaluation of indicators

The following chapter introduces the evaluation procedure, during which the indicators' inner workings were classified. We can see what area the state indicator covers, and through it, what performance indicators can be assigned to it. Furthermore, we'll also introduce what categorisation scale values were assigned according to. The following example illustrates the interpretation of "renewable energy aspect's" first indicator.

State indicator: *"Specific evaluation of energy mix used, and its general attributes."*

Reason for changing the indicator: The indicator was chosen because the analysed sector's specific production and consumption attributes determine how it can take part in the expansion of renewable energy production's subsystems, and if it can accept the energy forms from renewable energy production.

Performance indicator: Changes in the usage of non-renewable energy resources, increase or decrease in the rate of fossilized energy usage for the sector between 2020-2030.

Method of evaluating performance:

(-2) The share of non-renewable energy resources in the energy mix is highly significant: more, than 61%

(-1) The share of non-renewable energy resources in the energy mix is significant: 50-61%

(0) The share of non-renewable energy resources in the energy mix is optimal: 30-49%

(+1) The share of non-renewable energy resources in the energy mix is low: 20-29%

(+2) The share of non-renewable energy resources in the energy mix is not significant: less, than 20%

	Results for the 2010/2020 period	Results for the 2020/2030 period
Evaluation number	-2	-1

Explanation: If we look at the 2010-2020 time period, the share of renewable energy resources can be increased to 24%. However, in this time period, the level of fossilized input material usage is close to 62%. Currently, mostly natural gas is used to produce district-heating, where its share is nearly 81-82%, while the share of renewable energy resources amounts to around 12%. This share can be increased to 24% for district-heating by 2020. Increasing the share of district-heating until 2030 is possible up to 32%. The share of natural gas will probably be about 55% (Figure 4).

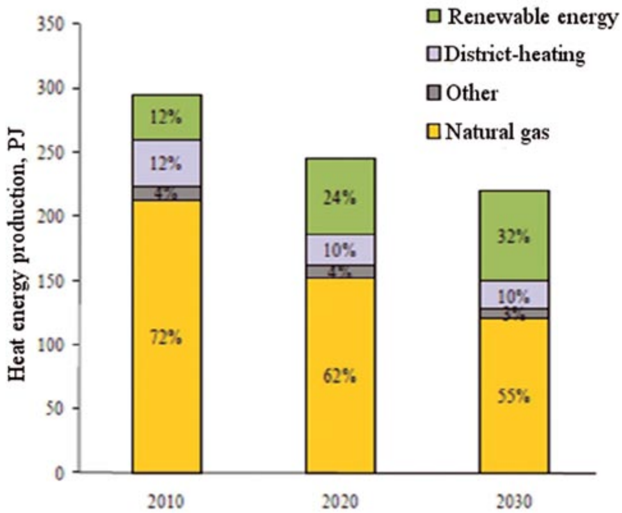

Figure 4. Role of renewable energy resources in heat production, 2010-2030 Source: [12]

3. RESULTS AND RECOMMENDATIONS

Summarizing the values of the analysis introduced in the previous chapter can be seen in Table 4. The Table's results show 3 summarization processes which are worth to evaluate on their own as well, using an overall analysis. The first evaluation form is the *"Net positive externality"* method marked with the letter *"A"*. This is a simple mathematical addition of localised externalities. The *"B"* category (*"Total externality ABS"*) however shows how many externalities surfaced within the given aspect in total, regardless of them being negative or positive. Finally, the *"C"* summarization is based on the other two, and illustrates how the system's total externality content's (B) positive externality content (A) is. As for the dimensions, we used three different approach within the aspects. The technological side obviously refers to how the technological solutions either used in, or applicable to the sector contribute to reaching climate goals. The environmental dimension evaluates how regulations synchronise with the goals. Analysing this is extremely important, since we could see that regulation mechanisms assigned to a given goal system produces contradictory results on different levels. Finally, the economic indicator group evaluates the role of subsidies from the perspective of developments' successes.

Dimensions		ASPECTS OF THE RATIO OF RENEWABLE ENERGY		ASPECTS FOR INCREASING ENERGY EFFICIENCY		THE ASPECTS OF CO_2 REDUCTION LEVELS	
		2010/2020	2020/2030	2010/2020	2020/2030	2010/2020	2020/2030
Technological	1	-2	-1	-2	-1	1	1
	2	-1	0	-1	0	-1	0
	3	0	1	-1	-1	1	2
Environmental	4	0	1	1	2	-1	0
	5	1	2	-2	-1	1	2
	6	0	0	-1	0	0	-1
Financial	7	1	1	-1	0	1	0
	8	-1	0	-2	-1	0	-1
	9	0	1	1	2	0	1
A: Net positive externalities ∑ (1;9)		**-2**	**5**	**-8**	**0**	**2**	**4**
B: Total externalities ABS (1;9)		**6**	**7**	**12**	**8**	**6**	**8**
C: The ratio of net positive external effects within total external effects		**0%**	**71%**	**0%**	**0%**	**33%**	**50%**

Table 4. Summarizing Table of the heating sector's benchmarking analysis

Explanation: A: Net positive externalities ∑ (1;9): the number of positive externalities within the various aspects in 2020 and 2030, respectively, if no directed climate policy developments take place outside of BAU; B: Total externalities ABS (1;9): the absolute value of the total number of externalities; C: The ratio of net positive external effects within total external effects; expressed as a percentage, it indicates the dimension of improvability in the studied area.

We can see in the results of the analysis that by 2030, apart from the aspect of energy efficiency, all the system's aspects are not optimal. This is not surprising for the aspect of energy efficiency, since even today's decision makers understood that this sector at this point requires the least effort to complete the climate goals of the European Union. In 2015, they stated that according to forecasts, the current business practice is sufficient to reach these goals, meaning they won't allocate further resources for this area [13]. However, the CO_2 emission reduction values are a different matter, where we can see that the heating sector would be capable of higher performance. If we look at the breakdown by dimension, we can see how most of the unused potential appears for technology, which in our case, could be provided by the spread of systems based on district-heating among consumers. Furthermore, concerning renewable energy resources, we can see that contrary to the previous case, technological requirements will be present by 2030, but the underproduction of the sector is due to the regulation and subsidy tools' inefficiency. Based on our previous demonstrative example, we can say that by 2030, the share renewable energy resources will have in consumption will be around 32%, which goes beyond the EU's 27% requirement. However, with this good a performance, further regulatory or financial motivators could be integrated into the system, so that it can work better within renewable energy resource usage. This makes the connection between the technology requirement and decision making and investment factors of optimal operation within the CO_2 aspect.

In the next part, let's take a look at the summary by dimensions (Table 5), where the main spectacle is the changes between indicator groups, which is why we depict them separately. The result of comparing the two evaluation types is that by 2030, the underproduction of regulations and the subsidy system can be seen, which are beneath the optimal value. Furthermore, we can see how in these categories, only positive externalities are generated by the end of the period. However, the technological dimension rated poorly during the previous Table's values shows a development tendency closing to the optimum. This is due to the breakdown by aspect allowing for energy efficiency to produce good results, but the technological aspect within it are still underproductive by 2030. We can see how this is the only indicator group that still produces negative values for this interval, looking at the Table. As a conclusion, we can say that energy efficiency in itself may really work optimally according to the different scenarios, but may contain elements, which hint at a bad structure even in long-term. This result signifies the "lock-in effect", which happens if necessary present developments aren't begun, since they look unnecessary, but when they do prove necessary later, they will be more costly [14]. As a final result, we can see that the Hungarian heating sector needs to invest in renewable energy resources, and heating systems based on district-heating t reach the optimum, and form strategies based on these points. However, we also have to note that we can't forget seemingly insignificant energy efficiency developments either, since discarding them leads to a bad structure in the future.

Aspects	Technological		Environmental		Financial	
	2010/2020	2020/2030	2010/2020	2020/2030	2010/2020	2020/2030
Renewable energy	-3	0	1	3	0	2
Energy efficiency	-4	-2	-2	1	-2	1
CO2 Reduction	1	3	0	1	1	0
A: Net positive externalities ∑ (1;9)	**-6**	**1**	**-1**	**5**	**-1**	**3**
B: Total externalities ABS (1;9)	**8**	**5**	**3**	**5**	**2**	**3**
C: The ratio of net positive external effects within total external effects	**0%**	**20%**	**0%**	**100%**	**0%**	**100%**

Table 5. Dimensional evaluation of the heating sector's externality analysis

4. CONCLUSION

The competitiveness of the heating sector is an important venture for Hungary, both from the social and environmental perspectives. The sector has potential for the introduction of renewable energy resource usage, and increasing its share, furthermore, using waste energy variants would also lead to the increase of energy efficiency. By modernising flats, and increasing the number of condos using district-heating solutions, environmental perspectives would get a greater exposure. The usage of biogas and storage gas, and feeding it according to regulated standards may create a decrease in the usage of natural gas for heating purposes. The increase in the district-heating system's size would decrease both fixed costs and direct costs long-term. The increase of the district-heating service's efficiency, advocating technological modernisation, and aiding the usage of renewable energy resources for heating purposes might be the next EU programming period's priority. Due to the increasing costs of natural gas is estimated to have on the world market in the future, the consumption-based subsidy system will probably put the budget under greater duress long-term, which has to be balanced by some solution, a possible contender being the subsidy systems motivating for efficiency. The modernisation of the pipes and the heating centre network is indispensable for the district-heating systems, accompanied by importing renewable energy resources, mainly by using biomass and geothermic energy, furthermore, the energetic usage of communal waste otherwise non-recyclable.

During the analysis, we shed light on the fact that though decision makers evaluated the long-term progress of energy efficiency in the sector adequately, its complete dismissal will lead to a deadweight anyway. This is why creating a regulatory and subsidy framework system that assures its optimal operations within the required technological solutions now is advised. Based on the analysis' results, the increase of district-heating's efficiency, advocating technological modernisation, and aiding heat production using renewable energy resources may become a priority for the next programming period. This includes the modernisation of pipes and the heating centre network, and importing renewable energy resources (mainly by using biomass and geothermic energy), and using otherwise non-recyclable communal waste as an energetic resource. The system's covered area should be increased to reduce fixed and direct costs long-term.

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