

District Heating and Cooling in Emerging Economies, In Search for More Realistic Vision

Marek Martin¹⁺

¹Technical University of Lodz, Poland

Abstract: Challenges of climate change and the need to secure sustainable economic growth and social cohesion require a deep change and so called “energy revolution” in order to reverse current unsustainable trends and meet various policy requirements. New policy regimes for environment and climate protection impose strict and demanding regulations on district heating (DH) and energy sector in general. Full implementation of environment and climate control policy regimes will require massive investment in district heating systems and will result with substantial increases in the prices of heat. This in turn may end up with limitation of proliferation of DH systems and objective inability to utilize the full potential of modern DH systems in emerging economies. Comprehensive DH modernization projects require time and massive investment, that not only in the period of economic slowdown is hard to comprehend. This paper presents briefly case study results of realistic modernization activities of selected DH plant in Poland, as an example of emerging economy. The modernization activities undertaken on the basis of realistic and appropriate technologies and concepts give unquestionably positive effect for environment, economy and society. This is probably one of the situations when “less means more” and pushing too hard may result with opposite results, degradation of the entire system and inability to sufficiently unveil the potential of DH systems in emerging economies.

Keywords: district heating and cooling, energy, emerging economies, energy systems.

1. Introduction

Heat for residential, businesses (commercial) and industrial purposes accounts for around 49% of total energy demand and about 47% of carbon emissions. In many countries DH subsector is far from unveiling its full potential (Poyry Energy 2009). The importance of district heating and cooling subsector has been diminished and neglected by policy makers for long period of time. Nevertheless it is by all means a vital element of entire energy system and its transformation and modernization represents the key element in transformation of entire energy sector and economy in general. The basic idea and source of substantial potential of competitive advantage of DH sector is concerned with taking advantage of local heat, cold (in case of District Heating and Cooling Systems – DHC) and various sources of energy that under “normal circumstances” would be lost or remain unused. The modern district heating and cooling systems offer a unique platform for utilization of various energy sources. In the case of modern European DHC systems, up to 90 % of energy comes from sustainable, renewable and recovered sources. The exploitation of full potential of DHC will strengthen energy security and reduce energy dependency upon import and therefore will support the foreign balance of trade. The implementation and proliferation of policies and practices for energy efficient buildings creates, from strategic perspective, a significant challenge for DHC, due to high capital intensity of the system and significant level of fixed costs. Morgan F, et al (2008) on the basis of Swedish perspective conclude that there are positive prospects for district heating also in the future, with more energy efficient buildings. In order to face energy efficient buildings challenge, it will require active and diligent work by district heating companies to stay competitive, but it is not necessarily so that electricity or natural gas will be the option of choice covering hot water demand or heat peak load in energy efficient

⁺ Corresponding author.
E-mail address: martin@p.lodz.pl.

buildings. In order to minimize climate impact from the building sector a system perspective for heat generation and provision must be used.

At present moment the level of development of district heating and cooling systems in European countries represent substantial differences in terms of i.e. utilized technology, capital engaged, availability (existing and potential) of renewable and secondary sources of energy. According to DHC+ Technology Platform Report (2009) at the moment there are more than 5000 district heating systems in Europe. The total level of energy supply of these systems reaches 10% of total European heat demand with the annual turnover close to 20 billion Euro. District heating is unevenly distributed among European countries, in some countries it very limited in the others it delivers up to 70% of the heat demand. Poland and Germany have the largest DH sectors relative to total heat markets. Austria and Italy are the main DH growing markets. In some cities (i.e. Copenhagen, Helsinki, Warsaw, Vilnius, Riga) up to 90% of residential heat demands are satisfied by district heat, others like for instance: Paris, Helsinki, Stockholm, Amsterdam, Vienna, Barcelona are on the way towards reaching 50% of district cooling shares. According to International Energy Agency (IEA 2008) energy consumption per capita is less in European Union Cites than those in USA and Australia, partly due to greater use of district heating.

2. District Heating in Emerging Economies, the Future of Coal

According to Polish Energy Regulatory Office (Energy Regulatory Office 2011), district heating sector in Poland is almost entirely based on hard coal the share of this fuel equalled 79,1% in the year 2002 and decreased to 76,0% in the year 2010. The share of other energy sources is less than 10% separately and equals in the year 2010: 7,5% for oil, 5,2% for gas and 5,7% for biomass, other sources of energy account for 5,6% of energy source portfolio. Dependence on coal is noticeable higher in DH plants operating without electricity cogeneration. In the case of DH plants operating with electricity cogeneration one can notice slightly higher dependence on oil and biomass. Coal is going to remain the most important primary energy source in the case of a number of emerging economies in the foreseeable future. Despite its high overall environmental footprint and high level of carbon dioxide emission per unit of energy, coal on one hand has got a number of advantages for local economies as the basic source of energy, on the other hand transformation of DH into systems based on other sources of basic energy i.e. gas and oil would require substantial investment and in the short and medium perspective seems to be unrealistic in the case of emerging economies. In addition moderate expected level of return on investment due to high prices of oil and gas discouraged potential investors in recent period of time.

From the strategic point of view, coal despite its high level of carbon dioxide emission has a number of convincing advantages. New technologies related to carbon dioxide capture and sequestration CCS and even more promising and potentially effective emerging biotechnologies aiming at transformation of carbon dioxide into bio-fuels, formulate different perspective on carbon as acceptable, from the environment and climate protection point of view, source of energy for the years to come. The roundtable discussion held at 35th Euro-heat & Power Congress (2011) helped to develop the SWOT analysis for coal, the key elements of round table discussion are specified underneath.

SWOT analysis for coal

Strengths

One of the four basic energy carriers used to produce electricity and heat in the EU

Fuel known and used worldwide, resources sufficient for the next 200 years

Competitive price in comparison to other energy carriers

Enables safe and faultless energy production

Ensures stability of energy system

Easy in transportation, storage and energy production regardless of climate

Weaknesses

High level of CO₂ emission

Opportunities

Positive impact on energy safety

Significant potential on the field of decreasing CO₂ emission (improvement of energy production efficiency, cogeneration development, implementation of new technologies such as CCS)

New legal regulations (for example a proposition to change, so called, „Energy Taxation Directive”

Threats

Legal regulations (ETS Directive and a project of IED Directive)

Assessment of the negative impact of CO₂ created in the process of coal combustion on the environment

Coal is one of four basic energy carriers used to produce electricity and heat in the EU. Despite its traditional and non or limited innovative connotations coal has a number of advantages despite one crucial drawback, that is high level of carbon dioxide emission. Therefore simple question arises is coal a wrong fuel, or is it just excessively high carbon dioxide emissions fuel. Technologies targeted to resolve this issue, are either just around the corner (CCS), or at the earlier stages of development (biotechnologies for capturing carbon dioxide), therefore it seems that coal as the main source of basic energy has got substantial future potential.

The utilization of gas as another basic source of energy in DH and entire energy sector enjoys a number of advantages, that is: relatively high elasticity in terms of the scale of investment, relatively short construction period, high overall process efficiency, low level of pollution emission, high output elasticity, relatively low initial investment. Energy systems based on gas also suffer from a number of disadvantages; the most important one is associated with relatively large share of fuel cost in the total cost in the period of normal exploitation. The prices of gas are hardly predictable and subject to significant variations. Increasing prices of gas in the recent period constitute one of important reasons of economic perturbations in some emerging economies (i.e. Hungary and Baltic Republics). Wider utilization of gas as the main source of basic energy requires unconditionally secure provision of substantial quantities of gas. Unfortunately in recent times lowering the level of gas supply proved to be an option for exerting political pressure on some European emerging economies. Due to high and unstable gas prices some DH establishments in Poland suffered substantial financial difficulties (Balcewicz, J., 2009).

3. Modernization of District Heating Plants in the Case of Emerging Economy– in Search for More Realistic Solutions

The problems of effective production, supply and utilization of thermal energy belong to the most important priorities of the Poland’s national energy policy. The issue does not only concern, related to the end user price level, static (short period) and dynamic (long period) energy production and supply cost optimization and effective utilization of energy, but also concerns the provision of sufficient level of security of supply and reduction of the burden for environment. The last and the most important from the point of view of this paper problem is concerned with, resulting from more demanding regimes of EU climate policy, the necessity of radical reduction of greenhouse gasses (GHG) emission. Therefore taking under consideration from one point of view, that currently utilized thermal energy production technologies based on coal suffer from the disadvantage of the highest level of GHG emission and from the other point of view, that the district heating subsector in Poland is almost completely based on coal, the requirements of substantial reduction of GHG emission and other harmful to the environment gasses and substances in the case of the district heating subsector in Poland combined with the provision of sufficient level of the security of supply are constituting at the present moment the most important challenge facing the national energy policy makers, the sector itself and energy recipients.

This challenge requires a number of activities and initiatives both on the supply and demand side. The activities on the supply side, addressed in the following section of the paper, ought to be focused on the improvement of energy efficiency of traditional processes of thermal energy production and distribution and

the growth of importance of low emission and renewable energy technologies. The most important activities on the demand side include the creation of conditions ensuring and supporting economical utilization of thermal energy by its recipients.

In the following section of the paper the highlights of case study of modernisation and refurbishment activities related to the district heating plant in the city of Wloclawek located in central-northern part of Poland are presented. The main priorities of the modernization effort are focused on the improvement of the level of efficiency and sustainability, reduction of waste and environmental burden.

The key priorities for modernization effort in the case of Wloclawek DH Plant include two broad categories:

- Initiatives for improvement of the process efficiency,
- Initiatives for improvement of sustainability of the DH system.

Two above mentioned categories seem to be to the large extent integrated and interwoven in a way that higher efficiency of the system supports overall sustainability via reduction of consumption of primary energy sources. Implementation of more environmentally friendly and sustainable technologies associated with i.e. larger scale utilization of for instance waste heat may on the other hand reduce the consumption of basic sources of energy and therefore positively impact overall effectiveness of the heat production and distribution process. Initiatives for improvement of the process efficiency identified on the basis of presented case study include:

- Refurbishment and modernization of heating boilers, or to certain extent new heating boilers erection. Utilization of new construction and technologies that allow for: (1) the reduction of energy losses via improvement of thermal isolation of heating boilers outer surface, (2) improvement of process efficiency via utilization of more refined technologies supporting more intensive internal heat transmission, (3) higher efficiency of chemical energy transformation into heat resulting, among other positive effects, in reduction of waste and by products,
- Modernization of pump and ventilation systems, high performance pumps and modern pump's control units allow lower consumption and utilization of electricity and better control and efficiency of the process. The main aim of modernization of pumps system was the maximal limitation of electricity consumption via implementation of electricity inverters and optimization and adjustment of output to actual system requirements. Modernization of pump system allowed for 71,5% reduction of electricity consumption per unit of heat. Annual savings on costs of electricity equals around 100 000 Euro. The payback time of initial investment associated with pump system modernization equals two years and eight months,
- Implementation of advanced integrated information and regulatory system allowing for better control and management of temperatures, pressures, flows, in the heat distribution system. This component also includes modernization of valves and shutters,
- Modernization of heat distribution pipes. Implementation of modern (pre-isolated) heat distribution pipes allowed for reduction of heat distribution losses from 13-17% to the 3% level,
- Modernization and liquidation of group heat distribution centers and transformation into individual – where it is possible - heat distribution centers. This process allows for better (more smart) control and management of the heat distribution process and creates stronger incentives for heat recipients to rationalize energy consumption.

Improvement of sustainability of the DH system, key measures include:

- Implementation of more efficient techniques for fumes filtering and separation via implementation of advanced sag filters. These measures allowed for reduction of dust emissions from 400 mg per cubic meter to maximum 100 mg per cubic meter. The EU regulations will force further improvement of the fumes filtering process to the level of 30 mg per cubic meter in year 2020. The implementation of modern filtering system allowed for 4 times lower emission of dust to the atmosphere, 2,5 lower emission penalty fees per year, improvement of filtering efficiency from 80% to 97%, high quality and durability of installation. On top of this the new filtering system gives the opportunity for utilizing lower quality of coal and offers a opportunity for fuel cost reduction in the process,

- Preparation of thermo-vision map of the city heat distribution system for the purpose of identification of low and degraded thermo isolation elements of distribution network.

4. Final Remarks and Conclusions

The transformation of DH subsector in emerging economies is a very complex and multidimensional issue. Exemplified DH plant is undertaking substantial improvement and modernization of heat generating and transmitting capacity at acceptable inherent pace. Acceleration of investment process will result with financial instability, excessive increase of heat prices for end users and in the process inability of unveiling the full potential of DH systems associated with its economy of scale, level of proliferation and utilization of secondary and renewable sources of energy, thought lower than potentially available share of centralized heat generation and provision. The realistic solutions and strategies aiming at more environmentally friendly and sustainable modernization of the particular DH system will require evolutionary progress. High capital intensity and reliance on objective conditions exemplified by availability of secondary sources of heat (i.e. waste heat, geothermal, etc) require more realistic policy regimes. Enforcement of radical and unrealistic changes of standards of environment and climate protection may result in the actual reduction of overall DH system efficiency and environment protection investment due to high burden of penalty fees. The realistic policy measures should take into account long term return on investment in DH subsector and objective conditions associated with historical burden and availability of secondary and renewable sources of energy. Even very modern DH systems may suffer from the limited availability of secondary or renewable energy sources. Enforcements of implementation of climate and environment policy regimes in the situation of objective inadequate supply or low quality of secondary sources of energy in relation to technology utilised by DH plants, might result in the actual degradation of the environment. Utilisation of low quality waste, bio fuels or other secondary sources of energy, often imported – as in the case of Poland, as a fuel for existing DH systems results in more environmental problems and causes social unrest.

Transformation of energy ecosystem and provision of sufficient supply of secondary and renewable sources of energy is beyond any doubts long term process. Imposition of excessive environment and climate protection burdens on undercapitalized emerging economy may result in economic slowdown, deeper budget deficit problems and proliferation of economic crisis which, at the present moment is probably as dangerous as global warming itself. Customers have free choice, if the price of centralized heat is too high, they can turn to alternative – decentralized sources of energy, the heat market in that respect seems to be more price responsive due to availability of close substitutes, than for instance electricity and other utility markets.

5. References:

- [1] Balcewicz, J. (2009), *Gas District Heating, Bad Signals*, Energy Gigawat (Energia Gigawat), (7) 2009,
- [2] IEA (2008), *World Energy Outlook, Global Energy Trends to 2030*, International Energy Agency,
- [3] Poyry Energy (2009), *The Potential and Cost of District Heating Networks*, Report for Department of Energy and Climate Change, Poyry Energy, Oxford UK,
- [4] Morgan F. , Reidhav Ch., Dalenbäck, J. O., Werner S. (2008), *Is There a Role for District Heating in Future Cities with Low Energy Buildings?* Paper presented at the 11th International Symposium on District Heating and Cooling, August 31 to September 2, 2008, Reykjavik, ICELAND,
- [5] DHC+ Technology Platform (2009), *District Heating and Cooling, a Vision Towards 2020-2030-2050*, DHC+ Technology Platform Report, Brussels,
- [6] 35th Euroheat & Power Congress (2011), *Reduce, Recycle, Replace, Doubling DHC Now* , Paris May 2011, Roundtable Discussion: DHC and the Future of Coal,
- [7] Energy Regulatory Office (2011), *District Heating in Figures 2010*, Warsaw 2011.