WORLD MARKET POTENTIAL FOR DISTRICT HEATING

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The overall world energy consumption is steadily increasing. It is expected to increase by almost 50% by the year 2015. About 33% of it is currently used for electricity generation. Of the rest, heat consumed for residential and industrial purposes, and the transport sector constitute the major components. Practically the entire heat market is supplied by burning coal, oil, gas and wood. Although some of the first reactors were used for heat supply (e.g. Calder Hall (United Kingdom), Obninsk (Russian Federation), Agesta (Sweden)), currently less than 1% of the heat generated in nuclear reactors worldwide is used for district heating. The heat market is an open challenge and there are signs of increasing interest in these applications.

The objective of this paper is to assess the market potential for the district heating in the near (before 2020) and long (2020-2050) terms.

While the technical details are covered briefly, emphasis is placed on the economic and other factors that may promote or binder the penetration of the nuclear option into the market for non-electric energy services.

The article characterizes district heating in terms of its market size, its prospects for nuclear technologies and the economic competitiveness of the technologies. The evaluation of these factors is based on a quantitative assessment of the ultimate market size and a qualitative ranking of the prospects for nuclear to penetrate the market.

Keywords: nuclear district heating, nuclear reactor, competitiveness, heat market.

1. Introduction

Today, nuclear energy is playing an important role in electricity generation, producing 17% of the world's electricity. It has proven to be safe, reliable, economic and has only a minimal impact on the environment. Most of the world's energy consumption is in the form of heat. The market potential for nuclear heat was recognized since the early days of nuclear power development. Some of the first reactors were used for heat supply, e.g.Calder Hall (United Kingdom), Obninsk (Russian Federation), and Agesta (Sweden). Now, many reactors are supplying heat for district heating in Canada, China, Ezech Republic, Russian Federation, Slovakia, Sweeden, Ukraine, etc. But the nuclear option could be better deployed if it would provide a larger share of the heat market. Nuclear energy can provide a clean alternative to the burning of fossil fuels for district heating. In several countries nuclear heat is already being used for this purpose.

Currently less than 1% of the heat generated in nuclear reactors worldwide is used for district heating , but the operating experience already exist and there are signs of increasing interest in these applications.

Overall energy consumption is steadily increasing and this trend is expected to continue well in the future.

Although, presently, the entire heat market is supplied by burning coal, oil, gas and wood there are reasons to belive that in the future a increase of the interest for non-electrical applications of the nuclear heat is possible. Some factors can contribute to this development:

- A increase a of the energy demand because of the population growth and the economic evolution, especially in the developed countries;
- The impact of climate change related to the necesity to reduce the gas emissions;
- Evolution of the nuclear technology for the comercial non-electrical aplications
- Changes in the social environment related to nuclear energy.

Though (Even) nuclear energy has been used to supply a portion of the heat demand, it is not yet achieved significant penetration. How far and how fast it could capture part of this market will depend mainly on how characteristic of nuclear reactors can be matched with the characteristic of the heat market, the dimenssion of the heat market, the nuclear source potential, on the economic competitivity of the nuclear sources and of course the public acceptance.

2. Heat market characteristics

Presently, around 70% of the global energy is consumed for heat supply, but the residential and the industrial sectors constitute the two major compoenets of he overall heat market. Within the residential sector, the demand for space heating and hot water is often supplied from a resonable distance by a centralized heating system through a district heating transmission and distribution network serving a relatively large number of customers.

District heating is a consequence of the heat demand and depend in principal of two elements: climate and the people capacity to buy the thermal comfort desired.

A possible market for district heating appears mainly in climatic zones with relatively long and cold winters. (eg. Finland, Denmark, Russia, countries where district heating is widely used.)

Partea de cerere de caldura care poate fi acoperita de incalzirea centralizata depinde de dezvoltarea istorica a sistemului energetic din tara respectiva.

District heating networks generally have installed capacities in the range of 600 to 1200 MW(th) in large cities, decreasing to approximately 10 to 50 MW(th) in towns and small communities.

Depending on the transportation distance and the number of end users, there are usually several pumping stations between the heating source and end users. Heat transport pipelines are installed either above or under ground. They are well insulated in order to minimize the heat loss.

The load factors of district heating systems depend on the length of the cold season when space heating is required, and can reach up to about 50%, which is still below what is needed for base load operation of plants.

To asure a reliable supply of heat by the district heating networks, a adequate backup heat generating capacity must be provided. Tis imply the necesity of redundancy.

Also, the transport of the heat is difficult and expaensive. The necesity of the pipiline, pumping, yhermal isolation, maintenance, heat losses make difficult the transportation at long distances because of the specific cost of transporting heat increase with the distance and the amount of heat transported will diminishes.

Presently the space heat and hot water demand can be supplied by different energy sources: coal, gas, oil, wood and electricity. Between this fossil fuels have an important place. All of this sources are already in competition and the tendency of the cuatomers to choose the type of the final energy will increase this competition.

3. Characteristics of the nuclear sources

There are plenty of experienceof using nuclear in district heating, so the technical aspects can be considered well proven. There are no tehnical impediments to the application of nuclear reactors s heat sources for distrct heating. In principle, any type and size of nuclear reactor can be used for these purposes.

Potential radioactive contamination of the district heating networks is avoided by appropiate precautions, such as intermediate heat transport circuits with pressure gradiens, which act as effective barriers. No incident involving radioactive contamination has ever been reported for any type of the reactors used for this porpose.

For nuclear district heating, there are basically two options: cogeneration of electricity and heat, and dedicated nuclear heating reactors.

Cogeneration has been widely applied and experienced. In the cogeneration mode, electricity will usually constitute the main product. Large size reactors have to be integrated into the electrical grid system and optimized for base load electricity production. For reactors in the SMR size range, and in particular for small and very small reactors, the share of process heat generation would be larger, and heat could even be the predominant product.

In principle, any amount of heat can be extracted from cogeneration reactors upon demand within the design limitations. However, when the extracted heat is a significant fraction of the reactor power, the impacts of heat and power fluctuations must be carefully analysed. If the heat load is fluctuating daily or seasonally, the electricity production will fluctuate as well. Technically it would raise no significant problem as long as the electricity generation is compatible with the grid load.

Heat only reactors have a different approach, although not much experience is available to share. There are some innovative design approaches for dedicated heating reactors.

A variety of reactor designs are being developed for district heating

Dedicated nuclear heating systems were designed and some built and operated in Canada, China and Russia. The plants in Canada and China were for demonstration purposes, whereas the Russian plants are to supply settlements in northern Russia.

Atomic Energy of Canada Limited (AECL) constructed and tested a 2 MW(th) SLOWPOKE demonstration reactor in 1980s. A 5 MW(th) Test Heating Reactor (NHR-5) was commissioned in China and has been in operation since 1989 supplying heat to the INET Center. Russia has operated a 10 MW(th) heating reactor at Obninsk for more than 20 years and has developed the technology of the nuclear district heating reactor AST-500. Construction of AST-500 reactors at the city of Voronez and Tomsk started in 1980s but was suspended in the early 1990s.

Nuclear cogeneration plants for electricity and district heating were built and operated in Bulgaria, Germany, Hungary, Russia, Slovakia, Switzerland and Ukraine.

The NPP Kozloduy in Bulgaria has supplied heat to the town of Kozloduy since 1990. The Kozloduy NPP consists of four WWER reactors of 408 MW(e) and two WWER reactors of 953 MW(e).

The Greifswald NPP in Germany (former GDR) has supplied up to 180 MW(th) for district heating until its decommissioning in 1990.

The Paks Nuclear Power Plant (Hungary) consisting of four units of the Soviet design WWER- 440 type V-230 is supplying heat to the town of Paks.

The Bohunice Nuclear Power Plant in Slovakia produces electrical energy and low temperature heat for heating and industrial purposes. The plant generates approximately 12 TW-h electrical energy annually.

The district heat extraction from the Beznau NPP (2 x 360 MW(e) PWR) has been operated reliably and successfully since its commissioning in 19983/84. Since the

The most extensive experience with district heat supply from nuclear cogeneration plants has been gained in in the Russian Federation. A research reactor at Obninsk has supplied heat since 1976 and is still in operation. The NPPs of Bilibino, Belojarsk, Balakovo, Kalinin, Kola, Kursk and Sankt Petersburg are supplying heat from steam turbine bleeders through heat exchangers to district heating grids of towns with typically about 50 000 inhabitants, situated between 3 and 15 km from the NPP site. The heat output capacities range from about 50 to 230 MW(th).

In Ukraine, the NPPs Rovno and South Ukraine have supplied heat to district heating grids since 1982 and 1983, respectively.

4. Economic competitivity

Essential conditions for the viability of nuclear heating systems are that the price of nuclear heat has to be competitive with alternative supply options, and that the heat production must be safe and reliable.

The economic competitivity of the non-electrical applications will follow the same trends as those for nuclear power production for generating electrocity.

At cogeneration plants, which constitute the vast majority of nuclear heat supplying plants, the main product is electricity. Heat delivery amounts usually to less than 10% of the total thermal power. The cost of the nuclear electricity will thus be decisive for the economic viability of a nuclear project, with heat supply as a byproduct.

Nuclear heat applications were found economic in a number of cases, but not under all circumstances. Cogeneration has thermodynamic advantages which usually lead to low energy cost, but the heat transport system and other necessary installations may be quite costly. Among other conditions, a large and fairly steady demand for heat or desalted water is essential for economic nuclear heat application.

For dedicated heat only reactors rhe competitiviness of non-electrical applications will strongly influenced ny the demonstration that the prposed nuclear reactors can be sited near population centres.

The main factors that would improve the competitiviness of nuclear options include lower specific overnight costs, shorter construction times, low discounts rates, the incorpotation of environmental externalities in the price of energy and the expectation of increasing fossil fuel prices.

5. Conclusion

The positive experience gained in the use of nuclear heat for district heating and the existing systems economical and socially accepted are a good basis for further development.

In general, the district heating market is expected to expand substantially. Not only because it can compete economically in densely populated areas with individual heating arrangements, but also because it offers the possibility of reducing air pollution in urban areas.

Some factors will encourage the development of the non-electrical applications. Among this are development of the innovative reactor concepts, in particular in the SMR range with improved safety features that will expected to improve the public perception.

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