NUCLEAR ENERGY
AN EFFICIENT SOLUTION FOR THE CO_2 PROBLEM ?

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Introduction

The development of the local and global climate is topic of many dicussions and conferences today. A growing scientific consensus states that man is influencing the climatic system by releasing more trace gases than the natural cycle will deposit at the same time. Although the magnitude of the future man-made climate changes is difficult to estimate, its dimension largely depends on the futural development of the energy sector - the severeness of the CO_2 problem is mainly influenced by the overall energy use and its structure according to the energy sources used.

A solution as the ultimate option or measure to reduce greenhouse gas emissions cannot be presented. Changing demand structure as well as interfuel changes due to different carbon contents of fossil fuels can have a significant impact on the emission level. Nuclear power besides other non-fossil fuels, has the highest CO_2 reduction that can be achieved. This paper focusses on the possibility to reduce CO_2 emissions from energy conversion in the supply system of the Federal Republic of Germany by increasing the use of nuclear energy for the production of electrical energy and by utilizing it for the generation of district heat.

Approach

This analysis builds up on a scenario by PROGNOS on the future energy supply and energy demand structures whereby the year 2005 is a focus point. The energy input during the period 1987 to 2005 for electricity and district heat production is assumed to grow about 27%. The corresponding CO_2 emissions in the year 2005 are about 323 million tons from electicity production - mainly from the fuel input of lignite (17%) and hard coal (39%). About 18 million tons CO_2 derive from district heat production in 2005 - mainly from hard coal (48%), gas (23%) and from oil (19%).

The technical CO_2 reduction potential takes into account those measures of substituting fossil energy conversion which can be realised looking from a technical point of view.

The costs of CO_2 reduction strategies must be investigated in comparison to typical alternative systems as they would be used instead of the suggested nuclear systems. Here the cost are calculated from the national economic point of view. The specific CO_2 reduction costs result from the difference of CO_2 emissions divided by the difference of costs.

The technical potential can be examined for its economy to recieve an economic CO_2 reduction potential. It covers those substitution measures where the nuclear system has negative specific CO_2-reduction costs - implying that the nuclear system can convert energy for lower specific costs than a comparable fossil system.

Electricity production

In the field of electricity production a possible substitution of coal by nuclear energy is analyzed. Nuclear power can stand in for both lignite and hard coal, which might be domestic or imported. Generally two possibilities are considered to increase the nuclear electricity production: increasing the load factor of nuclear power plants and substituting fossil power plants by nuclear power plants. A strategy based on the scenario by PROGNOS assuming the additional construction of two nuclear power plants each year starting in 1997 and primarily substituting lignite fired power plants results in a possible CO_2 reduction of about 88 million tons in 2005. If the load factor of all nuclear power plants is brought up to 7500 h/a the possible CO_2 reduction is 149 million tons per year.

The analysis of the costs of these potentials must consider the difference in price of domestic and imported hard coal. Figure 1 shows the difference of the specific CO_2 reduction costs for the subsitution of electricity production in coal fired power plants by nuclear power plants in dependency of the load factor. A substitution of fossil energy production by nuclear energy production with imported hard coal or lignite respectively elaborates to have negative CO_2 reduction costs if a utilization of more than 4000 h/a is assumed. Looking at domestic hard coal the CO_2 reduction costs are negative for a load of more than 1500 h/a. The fact of lower electricity production costs from nuclear power plants than from fossil power plants results that the whole technical potential is an economic CO_2 reduction potential.

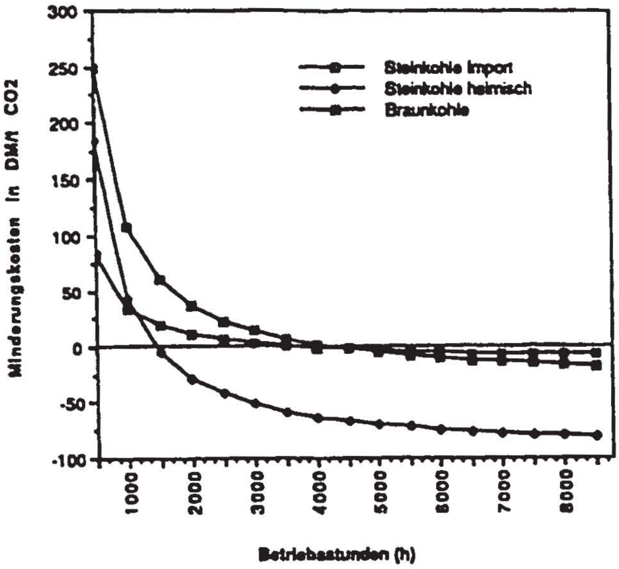

Figure 1:

Specific reduction costs due to the utilization hours of the fossil energy carrier been substituted by nuclear energy

District heat production

This chapter deals with the possibility to utilize nuclear energy for the supply of district heat. Generally there are two ways to supply district heat from nuclear sources: the heat extraction from large nuclear power plants with the heat transportation to a nearby district heat network and the implementation of nuclear heating plants.

The possibility of heat extraction from existing nuclear power plants and heat transportation up to a distance of 100 km to supply surrounding district heating networks is considered. The heat extraction is limited to a maximum of 500 MW_{th} out of a nuclear 1300 MW_{el} power plant. The technical potential of this measure in 1987 is scaled up according to the reference scenario into the year 2005 resoluting in a CO_2 reduction potential of about 5 million tons.

The other option to utilize nuclear energy for the district heat supply is to set up special nuclear heat sources in local networks called heating reactors. There are several concepts for this technology in a large power range from 2 MW_{th} up to 500 MW_{th}. This analysis bases on the age structure of the existing co-generation plants and on the thermal power which is expected to be added until the time of 2005 beginning in 1994. The technical potential for the thermal power of this strategy is about 8.7 GW_{th}- corresponding to nearly 800 MW_{th} of nuclear heating plants to be built per year. This measure resolutes in a CO_2-reduction potential of more than 6 million tons per year.

The costs of the heat extraction from nuclear power plants are compared to the average costs for the heat production in co-generation plants. The production in nuclear heating plants is compared to the fossil co-generation plants according to the used fuel. Figures 2 and 3 show the CO_2 reduction potential in dependency of the specific CO_2 reduction costs of different measures.

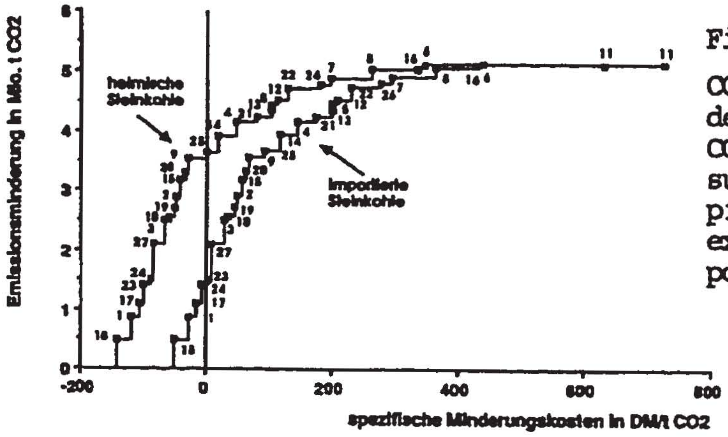

Figure 2:

CO_2-reduction potential in dependency of the specific CO_2-reduction costs of the substitution of fossil heat production by the heat extraction out of nuclear power plants

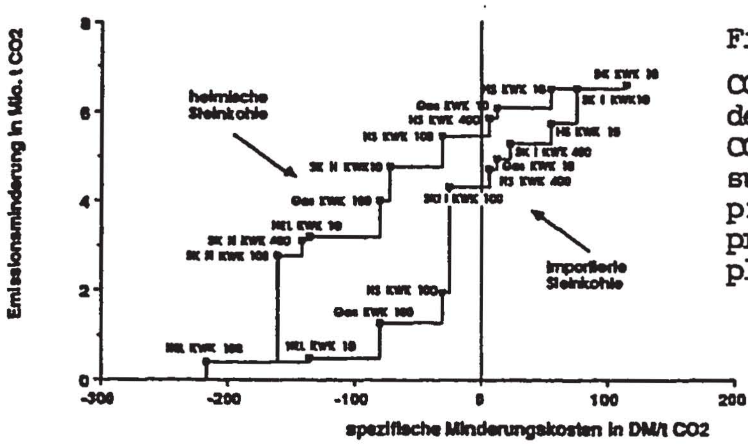

Figure 3:

CO_2-reduction potential in dependency of the specific CO_2-reduction costs of the substitution of fossil heat production by the heat production in nuclear heating plants

Conclusion

The analysis shows that nuclear energy can contribute to a significant CO_2 reduction, especially in the field of electricity production it has the potential to reduce CO_2 emissions with little or no additional costs. Although the extended utilization of nuclear energy is an efficient measure to reduce "grennhouse gas" emissions, it is not sufficient to reach the necessary reduction targets.