Efficient municipal energy systems reduce the environmental impact

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1. SYNOPSIS

Emission-related fuel fees can, with a negligible cost-increase, substantially reduce the environmental impact of municipal energy systems.

2. INTRODUCTION

Pollution-related fuel fees include environmental consideration in the economic conditions of fuel-usage. The economically optimal strategy for a municipal energy utility is calculated using present Swedish energy taxes and higher emission-related fees.

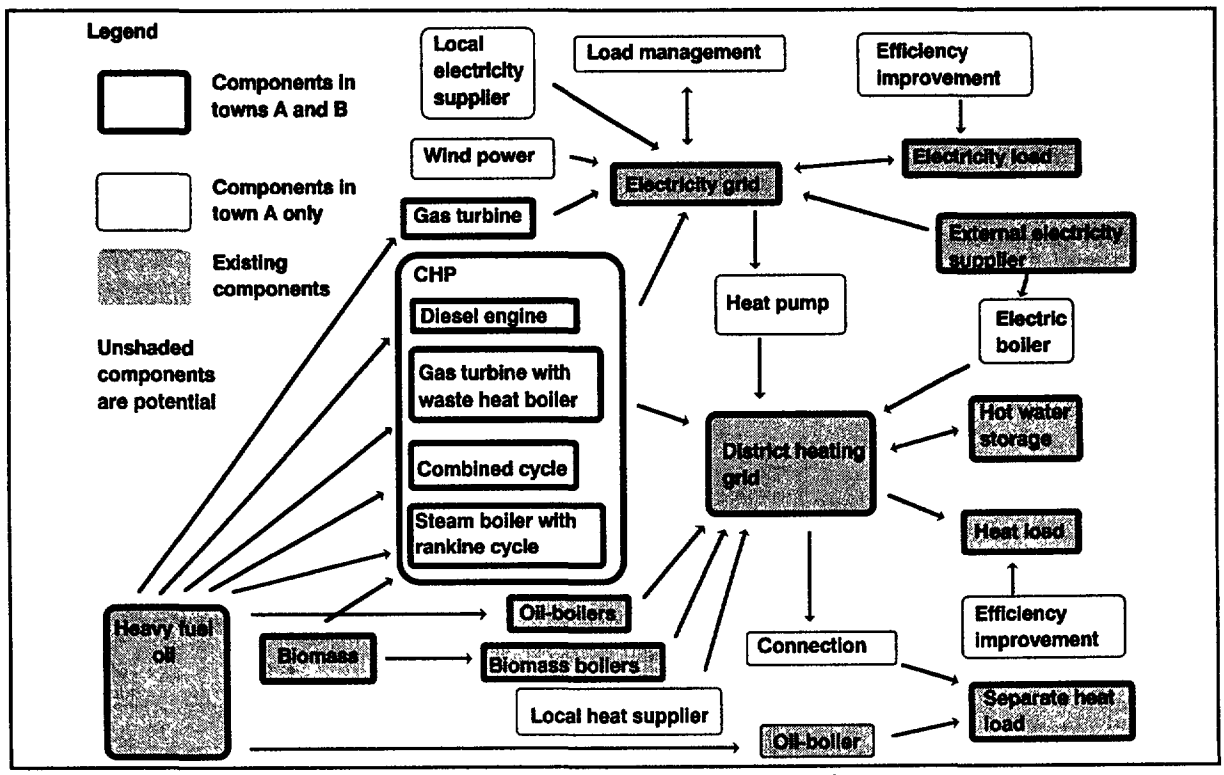

Figure 1. *Analysed electricity and district heating systems in town A and B*

3. METHOD

Many measures, like introducing combined heat and power production (CHP) or affecting energy demand, are considered simultaneously. The utility system cost, i.e. investment and operating costs during ten years, is minimised by linear programming. The size of e.g. a new CHP-plant is decided by the optimisation. Seasonal and diurnal time dependence is considered. (Henning et al. 1992, Söderström et al. 1991)

4. CASE STUDIES

The not-expanding electricity and district heating demand of two existing towns, A and B, is to be satisfied. Nuclear and hydro power electricity is supplied from outside. The heat production capacity is based to one third on biomass and to two thirds on oil. Biomass does not make a net CO_2-contribution. The peak (80 MW) and minimum (25 MW) electricity demand is similar in both towns as well as the district heating demand.

Average Swedish costs are used. Heavy fuel oil costs 10,2 ECU/MWh and biomass 9,1 ECU/ MWh. The electricity price ranges from 14 ECU/ MWh during summer nights to 34 ECU/MWh during winter weekdays. The peak load-related charge is 32 ECU/kWel,year. 1 ECU = 8,80 SEK (February 1993).

The present Swedish oil tax consists of a general energy tax (5,8 ECU/MWh), a CO_2-related tax (9,7 ECU/MWh) and a sulphur-related tax (1,2 ECU/MWh at 0,5 % S). The general tax is not paid for CHP and the CO_2-tax is not paid for electricity generation.

The higher environmental oil fee does not contain the general energy tax but doubled CO_2- and sulphur taxes, the same for all purposes. Moderate (2 %/year) and rapid (5 %/year) real value increase of the electricity rates are considered.

5. RESULTS

5.1. Town A

If the electricity rates increase moderately it is profitable to install a heat pump. With present taxation a gas

Table 1. ***Results of optimisation by different electricity price increase and environmental fees***

	Town	A	A	B	B
Electricity price increase	Environ-mental fees	present	high	present	high
moderate		(1)	(2)	(1)	(2)
CHP	MW el	-	-	2,7	6,7
System cost	MECU	120	121	136	140
CO2 emissions	ton/year	8700	2600	21000	800
rapid		(3)	(4)	(3)	(4)
CHP	MW el	12	4,0	14	6,7
System cost	MECU	129	132	150	153
CO2-emissions	ton/year	25800	2200	25600	800

turbine should produce peak electricity. Electricity purchase from e.g. a hospital and load management decreasing the peak load charge are always beneficial and so are reducing electricity demand and connecting the district heating grids. Purchased biomass-heat replaces some oil at high environmental fees. These measures make CHP less desirable.

By rapid electricity price increase an oil-fired gas turbine with waste heat boiler at present taxes, and a biomass-fired steam boiler with rankine cycle at higher environmental fees are profitable. The latter CHP-

plant is smaller due to its larger investment cost and lower electricity yield.

The emissions of CO_2 in the worst case (3) is more than ten times as large as in the best case (4) while the system cost is only 2 % smaller.

5. 2. Town B

With present energy taxation diesel-engine-CHP by moderate electricity price raise, and a gas turbine with waste heat boiler by rapid price raise are optimal. The latter is larger than in town A due to longer running time.

With environmental fees a biomass-fired steam boiler with rankine cycle should be built. Its size is independent of the electricity price increase since the CHP-plant is the sole heat supplier from May to August and biomass-heat is cheap (Figure 2). A part of the diurnal heat storage helps avoiding expensive heat production and increasing desired electricity production.

The carbon dioxide emissions are about thirty times as large in the worst case (3) than in the best (2,4) but the system costs only differ 2 %.

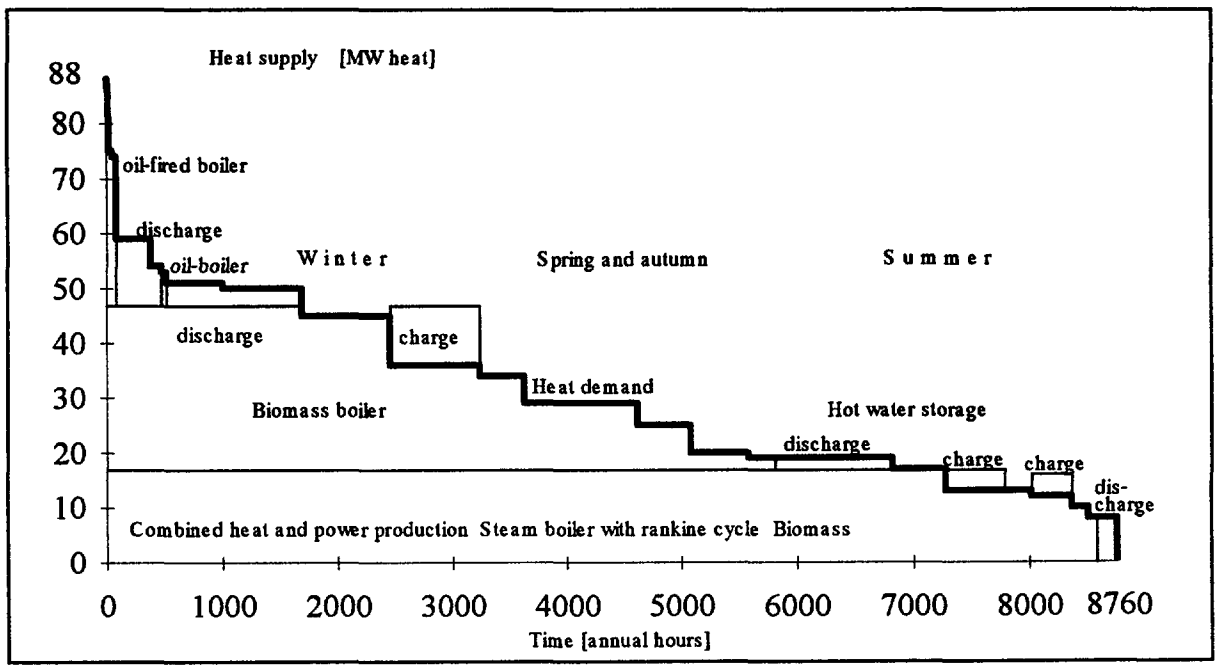

Figure 2. ***Duration diagram of heat supply in town B by high environmental fees***

6. CONCLUSION

The results show that through an environmental fuel fee considerable CO_2-emissions can be avoided while the cost of energy supply is raised negligibly if biomass is available.

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