ENHANCING ENERGY EFFICIENCY OF BIOMASS DISTRICT HEATING BY INTEGRATION OF THERMAL SOLAR ENERGY

Wolfgang Jilek
Department of Energy, Housing and Technology, Government of Styria, Landhausgasse 7, A-8010 GRAZ, Austria
+43 664 3577213; jilek.stmkgvat@gmail.com

1 INTRODUCTION

The province of Styria, Austria, has known a long history of biomass based district heating systems starting from the early 80ies and – after periods of doubts, success as well as grievous faults – leading to a supply system with an advanced quality management and a high level of acceptance.

One of the main problems of the smaller d.h. installations was caused by the fact that in summer only a comparably small amount of heat is needed and thus – for the summer period – many boilers were oversized which had an important – negative – impact on the profitability. One solution to avoid this situation is the implementation of a large solar system to cover the energy demand (for domestic hot water) in summer.

2 THE ENERGY PLAN OF 1984

After the oil crisis of the 70ies, the Government of Styria decided to change the energy supply of the province reducing the energy demand and using more renewable sources. With the "Energy Plan 1984" the Province of Styria, one of the nine Austrian "Bundesländer", intended to start a new age especially giving precedence to renewable energies. Else, the negative impact of energy use on the environment should be reduced by a reduction of the consumption.

At that time, the share of renewables was 16 percent of the overall energy use, 8 percent hydropower and another 8 percent biomass, mainly used for small boilers. Most of the remaining 84 percent had to be imported (15% natural gas, 34 % coal and 35 % fuel oil).

Starting with the step by step reduction of fossil fuels for the heat supply of subsidized dwellings (more than 80 % of residential buildings got subsidies at that time, due to a social housing programme) the need for solutions based on renewable energy sources rose and one possibility seemed to be the use of biomass, the Province of Styria being covered by more than 60 % of woods.

A chance, of course, even if it was clear that harvesting was quite difficult because of the topographic situation of the woods: most of them are situated on slopes or even steep slopes where machines like large harvesters (like in Sweden or Norway) cannot be used and every tree has to be cut and brought away in a sometimes really exhausting way.

3 THREE PERIODS OF DEVELOPMENT

3.1 three pilot projects

In 1985 three pilot projects introduced biomass for district heating using bark which had been treated as waste before. In spite of the lack of knowledge concerning advanced technical solutions and certainly also because of high financial support by the Government of Styria and the Federal Ministry of Agriculture and Forestry, Environment and Water Management (BMLFUW) they became an economic success, followed by many further projects.

3.2 Doubts and scepticism – period 1

The Government of Styria gave absolute priority to biomass used in district heating systems – facing the problem that there were just some few pilot projects and no confidence in such a solution of energy supply. Many people thought that the emissions would be quite harmful and after some few years every new project had to face one or even more local initiatives trying to prevent these installations.

Therefore, together with the Styrian Energy Agency "Landesenergieverein" and – later on – with the Austrian Federal Ministry of Agriculture and Forestry, Environment and Water Management (BMLFUW) and the national "Kommunalkredit Public Consulting" (KPC) the Government of Styria started to subsidize both investors of biomass d.h. systems and consumers who were willing to connect. The subsidies for the very first installations summed up to 70 percent of the investment, subsequently decreasing to 30 to 40 percent of the investment, depending on regional aspects and some other factors. Else, several campaigns to convince people that these solutions could be environmentally harmless – if done correctly – were launched and restrictive emission limits were fixed by law, the strongest ones in Europe at that time.

3.3 Euphoria and faults – period 2

While the first period of the development was mainly characterized by a deep mistrust in the technology, in economic aspects and in the environmental impact, step by step citizens and critical environmental protection organizations could be convinced that it was possible to minimize emissions and act economically successfully by using the best available technologies.

It was a first success, so far. But the following period of exaggerated euphoria (in the 90ies) was the worst one – flooding the region with a lot of inferior d.h. systems because of a lack of qualified planners and enterprises and the wish of more than hundred municipalities (at once) to start a biomass d.h. project as soon as possible.

In this period three main problems can be located:

1) a bad relation of heat production, length of the grid and heat demand of consumers; a simple rule was connecting at least 1 kW per meter of grid and sometimes that was even less than 0.3 kW, leading to enormous losses, high demand of electricity for the pumps and other devices etc.;

2) almost no heat demand in summer (less than 10 to 15% of the average heat demand in winter) and the need of supply because of domestic hot water demand and

3) bad financing conditions like a high amount of debt capital or high interests.

Many of the wrong concepts and planning consequences still cause problems and probably will cause them in the future. Up to now no biomass d.h. system has failed, but simply because the pressure on politicians was high not to let people freeze – and to raise some more money to support them.

3.4 Strict quality management – period 3

It was clear that inferior quality had to be avoided. Thus – following the initiative of the Government of Styria – the Austrian Federal Ministry of Agriculture and Forestry, Environment and Water Management started a tender to introduce a strict quality management. The tender was won by the Styrian Landesenergieverein (Styrian Energy Agency). Since 2004 the quality management ("qm heizwerke") is in place.

First, the quality management concentrated on the following areas:

1) Exact analysis of the (local) situation including heat demand, possible location of the heating plant and the grid, analysis of all kinds of obstacles from social to political ones;
2) right dimensioning of boilers and grids,
3) optimization of financing conditions
4) optimization of technical components.

With the growing experience of the staff doing the quality management the projects and the realized installations obviously became much better. The results of this initiative are presentable: Important ratios have been significantly enhanced like

- electricity input for pumps related to length of the grid (mainly by RPM regulated pumps), ranging from 3,5 to 14,1 kWh per MWh sold before could be lowered to less than 7 kWh per MWh sold (average);
- heat losses of the grid related to length of the grid, ranging from more than 10 to 48,5 % (20 % average) before could be lowered to less than 10 to 28,1 % (12,4 % average) after optimization;
- size of storage related to top heat load periods etc.

After 2004, a continuous development of high quality systems and grids took place and now most of the Austrian systems (more than 2000) are under control of the quality management.

An important fact has to be mentioned, too: Finally, the results could be achieved because of an excellent co-operation of many players:

- municipalities as well as politicians seriously interested in a supply with renewable energies,
- companies providing high quality,
- the Chamber of Agriculture convincing farmers to believe in the possibility of contributing to a future supply system by providing raw material like bark, wood chips and (later on) pellets,
- the Styrian Energy Agency providing energy consulting financed by the Styrian Government,
- the system of subsidized residential buildings forced to connect to biomass d.h. grids under certain conditions and
- the Energy Commissioner of Styria providing subsidies and coordinating the activities of the mentioned players.

4 SOLAR ENERGY FOR LOW LOAD PERIODS

The quality management was quite a success and lead to much more sustainable systems. Nevertheless, low load periods still cause (economic) problems. Some of the grids stop delivering heat during the summer period and leave the problem to other technical solutions like electric boilers, but in general people connected to a biomass d.h.

grid expect to be supplied by renewable energy from biomass all over the year.

One possibility is adding large thermal solar fields to provide summer supply.

4.1 Solar energy for everyone?

The Styrian Energy Plan emphasized the need of using more renewable energies like biomass and solar energy. Intensive use of (thermal) solar energy was started in a private initiative of ARGE Erneuerbare Energie (renewable energy working group) 30 years ago. By means of organizing do-it-yourself groups, this association succeeded in achieving a high level of know-how, perfect logistical handling and an extremely high level of acceptance of solar facilities in private residential buildings. Due to this technical advance and the large number of facilities currently in use (in the eighties around 2,000 facilities with 25,000 m² solar collectors were installed annually in Styria alone), the specific costs of collectors had significantly dropped. Moreover, private DIY installation of solar facilities had such an extremely favourable impact on the solar market that many facilities had also been installed by companies in the wake of the DIY movement; today, almost no more DIY systems are installed, but the market has grown rapidly (after 2010 around 75,000 m² solar collectors were installed annually in Styria) and during the last years Austria had supplied more than one third of the European thermal solar collector market.

Measures implemented by the Styrian authorities, subsidies from housing schemes, and from 1992 on funds specifically earmarked for promotion of solar energy, had considerably supported the development of the use of solar energy. In 2008 the use of solar energy for domestic hot water was made mandatory for subsidized new residential buildings (and fuel oil was not allowed any more, the use of natural gas was restricted to some areas) and in 2014 the mentioned mandatory use of solar energy was fixed in the Styrian building code (in Austria the building codes are installed on the provincial level). In 2015, almost one million solar collectors was in use in Styria – almost one m² per inhabitant. Apart from the success of biomass district heating, it is above all the use of solar energy that has made a name for Styria in Europe.

4.2 Thermal solar energy for biomass d.h. systems

In a conference in Gleisdorf/Styria in 2015 dedicated to district heating and integration of solar energy experts and investors already showed much experience in the field of solar integration. Selected operators of biomass d.h. systems reported their positive practical experience with the integration of thermal solar (and PV) installations (and condensing boilers) mainly under favourable framework conditions (hydraulic concept, configuration of the boiler, size of storage, level of return temperature etc.) in order to raise the profitability. Integration of solar energy, used in a clever way, turned out to be a solution with a lot of potential.

One reaction of the subsidizing institutions, above all Kommunalkredit Public Consulting (KPC), which manages and administrates the subsidies provided by the Federal Ministry of Agriculture and Forestry, Environment and Water Management, was allowing to use a better rate of use in economic calculations when solar energy, waste heat or condensation are integrated. The Austrian Climate and Energy Fund, which had already developed around 111 different promotional programmes since its foundation in 2007, offered a subsidy programme during several years especially designed for “big solar” installations; until 2015 25 projects (6 of them feeding large urban grids, 13 being integrated in municipal systems and 6 “microgrids” supported by solar devices) were realized and the results are accessible, showing how to realize such systems in an economically reasonable way.

In 2016 in this programme the realisation of big solar devices will be supported as follows:

- solar process heat in production plants,
- solar feed in for d.h. grids,
- high solar coverage ratio (more than 20 % of needed amount of heat) in service companies,
- new technologies and innovative approach.

Else, the subsidized systems have to provide measured data and these will be gathered, analysed and evaluated and results will be available for Austrian companies. Subsidies cover up to 10% of relevant investment costs.

In Styria (and in some other provinces) the idea came up to combine subsidies for biomass d.h. and solar energy, even set up a new subsidizing scheme for combined systems. In addition, Styria has some good experience with participation models: In order to prevent large PV fields on the ground, in 2014 a tender was set up for citizens to take part in on roof-PV installations up to 200 kWp and this became an overwhelming success. So obviously there should be a potential for financing large thermal solar devices integrated into biomass d.h. systems that way – this may probably be introduced as a further incentive in the near future. In Styria, some 600 biomass based d.h. systems exist already. Many of them could

profit from the experience of the already existing integrated systems.

4.3 Big solar for 300.000 residents in Graz?

The city of Graz with its nearly 300.000 inhabitants and further 200.000 closely around is supplied by a coal based co-generation plant of 500 MW – old, environmentally acceptable only in the past because of enormous efforts to reduce dust, sulphur and nitrogen emissions and limited by contract (to be shut down by 2020) – which has to be replaced. Many options had been analysed and one of the main results – also referring to the Styrian "Energy Strategy 2025" – is that there is the possibility to use a considerable amount of renewable energies, including much waste heat from industries in and around Graz and a really large thermal solar collector field of 500.000 m². In 2016 a first step should be realized (around 10.000 m²), being followed by further parts of the big installation within the next years.

4.4 Large integrated systems

Some large integrated systems exist already in Styria and in Austria, usually not comparable to large solar systems in Denmark because of very different framework conditions, especially referring to energy price levels in Austria and in Denmark. But the Danish example at least triggered new ideas also in Austria, perfectly going hand in hand with possible solutions especially for the existing low load problems of small and medium biomass d.h. systems. Together with quality management and sophisticated technological solutions new ways of financing like participation models might help to realize many more installations in the near future.

Finally, these combined systems can play an important role in the implementation of the European Energy Efficiency Directive – which points out the necessity of using more efficient energy systems and lowering the energy demand – and for the reduction of climate relevant emissions, including a growing share of renewables.

5 SUMMARY

Besides solar energy use, district heating based on biomass is one of the success stories of Styria (Bundesland Steiermark), Austria. Starting in the early eighties with some few pilot projects, biomass district heating became one of the main energy sources for heating: By now, more than 600 DH systems provide heat for almost every second municipality in this region of 1.2 million inhabitants. A strict quality management (for all Austrian provinces) had been introduced in 2004 raising the efficiency of both heat production and distribution grids.

Nevertheless, summer is still a challenge especially with new low energy buildings and refurbishment of existing ones. An efficient solution is adding big (thermal) solar – already realized in some d.h. systems – it may provide a significant contribution for a decarbonized future.

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