Innovative Sanitation Concept Shows Way Towards Sustainable Urban Development

- Experiences from the model project “Wohnen & Arbeiten” in Freiburg, Germany -

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Abstract

In Vauban, a suburb of Freiburg, Germany, a new model house built in 1999 combines highly innovative energy, waste and sanitary concepts with a framework for a comfortable social environment.

Social, legal and financial framework of the project “Wohnen & Arbeiten”

The special situation in the Freiburg Vauban district is that citizens are encouraged to form groups and to apply for plots of land in the new district. The association “Forum-Vauban e.V., Freiburg” [http://www.forum-vauban.de/], founded by citizens of Freiburg, is the legal organizing body of the extended citizen participation. It has been successful with its concept to give the land in the Vauban district to groups of citizens with clear priority, while only a small part of the land will be given to conventional building constructers.

Fig. 1 The Model-House “Wohnen & Arbeiten“

The group “Wohnen & Arbeiten” is one of about 30 such groups of citizens having developed houses according to their wishes and ideas [http://www.vauban.de/wa].

In order to develop an innovative energy concept and an innovative sanitation concept for “Wohnen & Arbeiten”, an Association had to be formed being able to cooperate with research partners. Therefore, the “Ökobauverein e.V., Freiburg (Association For Sustainable Buildings)” [http://www.vauban.de/oekobau.html] was founded. This association is able to apply for funds and to handle the financial aspect as well as to run the experimental project phase. All future residents of the model house became members of the “Ökobauverein” and signed a contract that they will cooperate with the research projects.

Funds for the development and implementation of the innovative energy concept were allotted by the DBU (Deutsche Bundesstiftung Umwelt). “Wohnen & Arbeiten“ implemented this project jointly with the Fraunhofer ISE, Freiburg.

Funds for the development and implementation of the innovative sanitation concept (vacuum plant, biogas plant, water filter) were allotted by the DBU (Deutsche Bundesstiftung Umwelt), Fraunhofer Institute ISI in Karlsruhe, and TBW GmbH in Frankfurt. TBW and Fraunhofer implemented the project jointly with Ökobauverein e.V., Freiburg. A subcontract was given to the company Roediger, Hanau, for the construction and maintenance of the vacuum system. The biogas tanks were developed with and built by Mall-Umweltsysteme who also sponsored parts of the grey water filter.

Tab. 1 Technical and general data of the solar-passive house “Wohnen & Arbeiten“

General Data:	
dwelling and effective space	1.500 m^2 (16.250 squ.. feet)
number of flats	20 (incl. 4 offices)
number of residents	40 (incl. 10 children)
co-generation plant:	
electrical power production	5,5 kWh
heat energy production	14,5 kWh
Solar power :	
photovoltaic device	3 kWp*
thermal solar installation	15 kWp* (45 m^2 = 475 sq. ft.)
Triple-glass windows:	
k(or u)-value**	0,7
g-value***	0,6
Energy consumption:	
heating energy consumption per m^2 and year	13,2 kWh/m^2a (= 1,4 kWh/square foot*a)
total energy consumption for heating	20.700 kWh/a
total energy consumption for warm water	23.500 kWh/a

* = kilo watt peak ** = heat loss *** = light loss

Sustainable Energy Management

Due to the energy concept, residents need only 20 % of the primary energy (electricity and heating energy) used in conventional houses. All energy saving investments are strictly controlled by the cost-efficiency ratio. The costs are only about 7 % higher than in conventional houses and amortize over 10 - 20 years, which makes the house affordable for average German citizens.

In summer, hot water consumption is 100 % provided by a thermal solar installation, in winter it is supplemented by a small co-generation plant using natural gas.

Electricity is 60 % provided by the co-generation plant (50%) and a photovoltaic device (10 %). Optimal insulation, the utilization of active and passive solar energy, the triple-glass windows, and an 80 % reduction of aeration heat loss save 85 % of the heating energy over the year, compared to conventional houses (Frauenhofer ISE, Gruppe Solares Bauen 2001).

Sustainable Water Management

A combined vacuum sanitation system was projected for the model house. The idea of the sanitation concept is that biological waste, faeces and urine (the so-called "black water") are transported from the water saving vacuum-toilets to a biogas reactor with vacuum pipes. The reactor produces liquid fertilizer as well as biogas used for cooking. After having been cleaned in a grey-water-filter, the remaining wastewater from kitchens and bathrooms (grey water) is used again for flushing the vacuum-toilets and rinsing the garden. Rainwater flows through open gutters and is collected in two ditches. These two ditches are connected to the groundwater strata with packages of gravel, so the rainwater is filtered before reaching the ground water.

Some data and experiences for the development of the Biogas-Bio-Fertilizer Module were gained with the help of a pilot plant. This experimental Biogas plant was operated during 6 months in preparations of the Project “Solar-Siedlung, Freiburg Vauban”. (Lange 1997, Müller 1997)

A detailed analysis (Schneidmadl et al. 1999) compared conventional and sustainable water management and assumed the following reduction of water consumption and emissions into water:

- water consumption is reduced by about 50 %,
- carbon emissions by about 70 %,
- nitrogen emissions by about 90 %,
- phosphorus emissions by about 60%
- AOX (absorbable, organic halogens) emissions by about 48%, respectively, and
- copper emissions by 47%.

The separate treatment of grey and black water and the recycling of nutrients to agriculture could be an energy-efficient long-term solution for water management.

The Primary-Energy-Consumption of the innovative sanitation concept in the Model House “Wohnen & Arbeiten” was analysed and compared to the situation in Lübeck Flintenbreite and in conventional houses (Peters 2002).

Experiences Gained in The Project "Wohnen & Arbeiten"

The experiences gained during three years with the vacuum-system and the grey water filter, as some information on the biogas plant are given below.

The Grey-Water-Filter

The grey-water-filter was implemented in 1999 in form of an aerated sand filter and its performance was monitored (Steeger-Ballbach 2001). Due to technical problems, this filter is now replaced by a membrane-filter-module (Ultra-Sept-Pendelmodul) provided and co-sponsored by the company Mall-UMWELTSYSTEME (Donaueschingen, Germany).

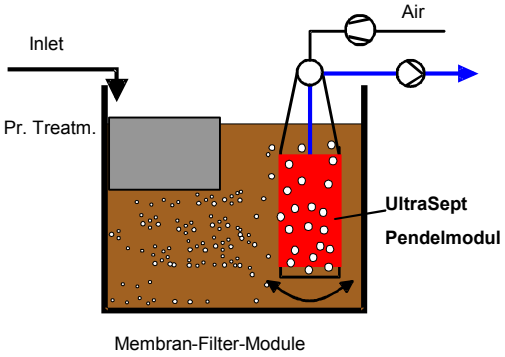

Fig. 2 The UltraSept Pendelmodul

The Vacuum-System

The vacuum system has been working since 1999 with hardly any technical problems. The acceptance of the vacuum-toilets by the residents is very good. In the initial stage of the project, the residents assumed, that the unusual noise of the vacuum-toilet could be a problem but this aspect turned out to be absolutely uncomplicated.

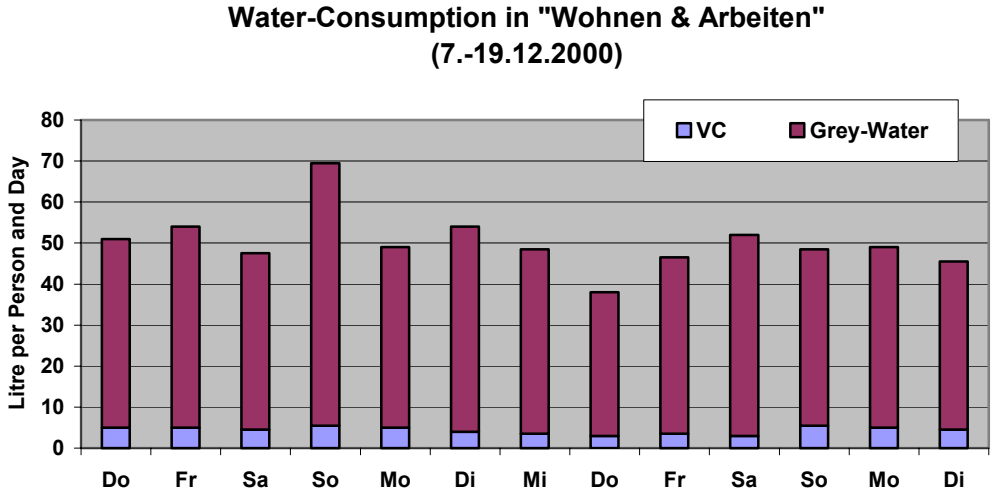

Fig. 3 Daily Water Consumption in the Model-House "Wohnen & Arbeiten"

Fig. 4 Vacuum Pumping Station (Left) and Vacuum-Toilet of the Model-House

The Vacuum-System is maintained by the company ROEDIGER, (Hanau, Germany). It reduces the amount of Black-Water produced per person and day to about 6 litre - which is a reduction of 80% if compared to an average German household.

The Biogas-Bio-Fertilizer Module

The first biogas plant for an apartment building in Germany consists of a concrete digester for treating black water and organic household waste, a post treatment with an internal plastic bag gas storage and a storage tank for the fertilizer.

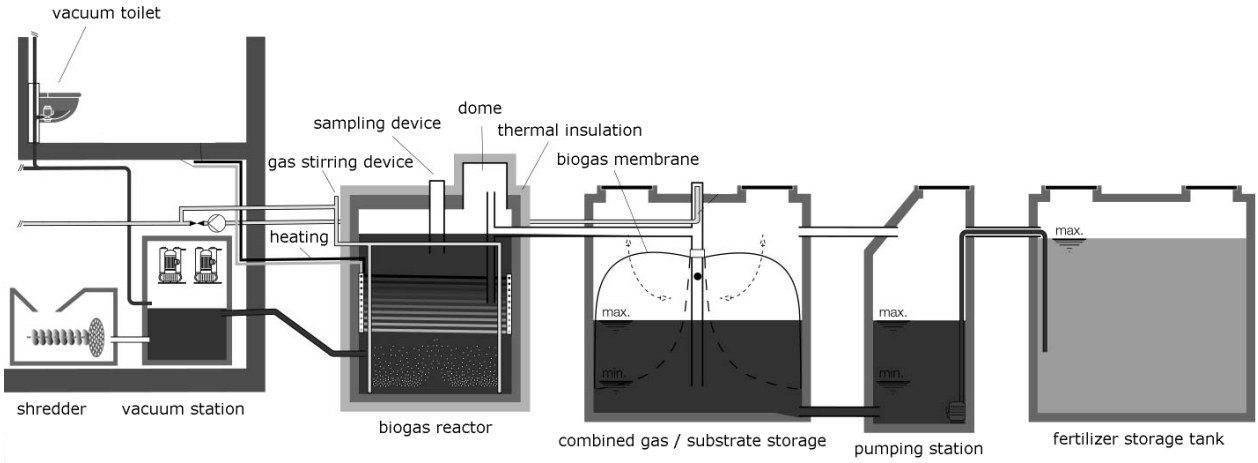

Fig. 5 The Biogas-Bio-Fertilizer-Module projected for „Wohnen & Arbeiten“ in Freiburg, Germany

The biogas plant is connected to the internal gas system of the house; it will provide cooking gas for the 16 households. The plant is almost ready – only the automatic regulation of the gas pressure and the feeding device for organic household waste need modification and adjustments.

The following table summarizes general and technical data of the sanitation concept of the model house “Wohnen & Arbeiten” in Freiburg Vauban, Germany.

Tab. 2 Technical and general data of the sanitation concept of “Wohnen & Arbeiten“

Number of Residents	40 (incl. 10 Children)
Vacuum-System	
number of Vacuum toilets	25
amount of water needed for flushing	1 l
amount of air used for flushing	20-40 l
Biogas-Bio-Fertilizer-Module:	
Biogas-Reactor	6 m^3
Bio-Fertilizer Storage-Tank 1	3 m^3
Bio-Fertilizer Storage-Tank 2	14 m^3
Bio-Gas Storage-Tank	9 m^3
Bio-Gas Production (anticipated)	2-3 m^3/d
Black-Water input per day (anticipated)	0,24 m^3/d
Organic Waste input per day (anticipated)	...0,02 m^3/d
Bio-Fertilizer Production (anticipated)	0,26 m^3/d
Grey-Water-Membrane-Filter :	
grey-water-input per day	2 m^3/d
Membrane surface	16 m^2 (Mall Ultrasept)
primary treatment	1 m^3 (Mall Ultrasept)
sludge treatment	4,5 m^3 (Mall Ultrasept)
power for aeration pump	500 W
Black-Water-Production reduced by:	**80%**
Black-Water-Production (average German Household)	35 l/d***
Black-Water-Production (Model-House “Wohnen & Arbeiten”)	6 l/d

*** = Data from: „Bundesverband der deutschen Gas- und Wasserwirtschaft, KA 12/97“

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