European Commission
Directorate-General for Energy (DG XVII)

THERMIE

European Workshop

RENEWABLE RURAL ENERGY APPLICATIONS IN NORTH-EAST EUROPE

A Thermie Programme Action

Helsinki, Finland
14-17 April, 1997

PROCEEDINGS

SOLPROS, Finland
AEE, Austria
KANENERGI, Norway

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FOREWORD

This workshop is part of the E.C. Thermie B project "Dissemination of Promising Renewable Rural Energy Applications in North-East Europe". The project manager is Arbeitsgemainschaft Erneuerbare Energie from Austria and the partners are SOLPROS AY from Finland and Kanenergi AS from Norway. The main organizer of the workshop and the editor of the proceedings is SOLPROS AY.

The workshop has been sponsored by the following organizations:

Main sponsors:
- European Commission DGXVII
- Ministry of Trade and Industry of Finland
- Technology Development Centre of Finland/OPET Finland

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- Imatran Voima Oy, Finland
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- Neste Oy NAPS, Finland
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THERMIE (1990-1994)

This is an important European Community programme designed to promote the greater use of European energy technology. Its aim is to assist the European Union in achieving its fundamental objectives of:

- improving the energy supply prospects of the European Union;
- reducing environmental pollution by decreasing emissions, particularly those of CO_2, SO_2 and No_x;
- strengthening the competitive position of European industry, above all small and medium-sized enterprises (SMEs);
- promoting the transfer of technology to Third Countries;
- strengthening economic and social cohesion within the European Union.

The majority of the funds of the THERMIE Programme are devoted to financial support of projects which aim to apply new and innovative energy technologies for the production, conversion and use of energy in the following areas:

- rational use of energy in buildings, industry, energy industry and transport;
- renewable energy sources such as solar energy, energy from biomass and waste, as well as geothermal, hydroelectric, and wind energy;
- solid fuels, in the areas of combustion, conversion (liquefaction and gasification), use of wastes and gasification integrated in a combined cycles;
- hydrocarbons, their exploration, production, transport and storage.

The THERMIE Programme (1990-1994) includes a provision for the enhanced dissemination of information to encourage a wider application and use of successful energy technologies. This information is brought together, for example, in publications such as this Maxibrochure. Maxibrochures provide an invaluable source of information for those who wish to discover the state of the art of a particular technology or within a particular sector. The information they contain is drawn from all Member States and therefore provides a pan-European assessment.

To guarantee the maximum effectiveness of the funds available, the THERMIE Programme (1990-1994) includes an element for the co-ordination of promotional activities with those of similar programmes carried out in Member States and with other European Community instruments such as ALTENER, SAVE, SYNERGIE, JOULE, PHARE and TACIS.

JOULE - THERMIE (1995-1998)

the first phase of the THERMIE Programme ran from 1990-1994 and had a budget of around 700 MECU. From 1995 the bulk of THERMIE activities will be carried out, with a budget of 530 MECU, as the demonstration component of the Non-Nuclear Energy Programme (JOULE-THERMIE) under the Fourth EC Framework Programme for Research and Technological Development. This change is based upon a concept within the Treaty on European Union to bring all research, development, demonstration and dissemination efforts of the Union closer together.

However, to continue all the activities corresponding to the former THERMIE Programme (1990-1994), a successor programme called THERMIE II, outside the Framework Programme, is currently under discussion in the Council of Ministers.

E.C.Thermie (DGXVII)
Workshop on
Renewable Rural Energy Applications in North-East Europe

PROGRAMME

Neste House, Keilaniemi, 02150 Espoo, Finland

Monday, April 14, 1997

General Possibilities
(chair: Dr. Faninger-Lund)

09:00-09:30	Registration and Coffee
09:30-09:45	Welcome and Introduction • Dr. Heidrun Faninger-Lund, SOLPROS, main organizer of workshop • Mr. Werner Weiss, AEE, project manager • Mr. Aimo Aalto, Ministry of Trade and Industry of Finland • Mr. Heikki Tikkanen, Neste Advanced Power Systems
09:45-10:45	Presentation of Participants and Companies • 2 minutes persentation of each participant • indication of interest
10:45-11:00	Break
11:00-11:30	European overview on solar thermal, photovoltaics and biomass • Mr. Matti Heikkilä, E.C. Opet-network
11:30-12:00	Innovation system and energy technology - case Finland • Mr. Kari Komulainen, Technology Development Center of Finland
12:00-13:00	Lunch

Market potential of renewable systems
(chair: Mr. Fritjof Salvesen)

13:00-13:45	Renewable Energy in Latvia • Director Peteris Shipkovs, Latvian Energy Agency • discussion
13:45-14:30	Rural renewable energy in Estonia • Dr. Teolan Tomson, Energy Research Institute, Estonia • discussion
14:30-15:00	Coffee Break
15:00-15:30	Renewable energy for rural electrification • Dr. Dimitri Strebkov, VIESH, Russia
15:30-16:00	Marketing forecast of renewable energy equipment's application in the Russian rural sector • Dr. Vladimir Kozlov, Alternative Energy Company, Russia
16:00-17:00	Discussion: Implementation Strategy

Tuesday, April 15

Technology and Applications
(chair: Mr. Werner Weiss)

09:00-10:00	Presentation of the techno-economic analysis of renewable energy in rural areas of North-East Europe • Mr. Fritjof Salvesen, KanEnergi, Norway • discussion
10:00-10:30	Practical experiencies of small-scale heat generation from fuelwood in Finland • Mr. Seppo Tuomi, Work Efficiency Institute, Finland • discussion
10:30-11:00	Coffee Break
11:00-12:00	Basic System Types: Design and Examples • Mr. Werner Weiss, AEE, solar thermal • Mr. Fritjof Salvesen, KanEnergi, biomass • Dr. Peter Lund, Helsinki Univ. of Tech., photovoltaics
12:00-13:00	Lunch

Business Forum
(chair: Dr. Faninger-Lund)

13:00-15:00	Business Forum: Company Presentations • activities and products • discussion
15:00-15:30	Coffee Break
15:30-17:00	Business Forum: Team Discussions • scheduled mutual discussions

Wednesday, April 16

Practice and Projects
(chair: Mr. Fritjof Salvesen)

09:00-12:00	System Technology (3 parallel sessions) • planning, design tools,economics • implementation, practical experiencies Sessions: PV-Biomass-Solar Thermal
10:30-11:00	Break
12:00-13:00	Lunch
13:00-14:00	EU-Financing • Mr. Henrik Moliis, Project Promotion Unit, Ministry of Trade and Industry • discussion
14:00-15:00	Business Forum: Team Discussions • scheduled mutual discussions
15:00-15:30	Coffee Break
15:30-16:00	Business Forum: Team Discussions
16:00-17:00	Moderated Final Discussion (chair: Dr. Peter Lund) : Realization of projects

Thursday, April 1

Technical Excursions

08:00-11:00	Visit Tour 1: IVO Oy Koppamäs renewable energy demonstration park
08:00-11:00	Visit Tour 2 : WP Oy, mini-hydro demonstration
11:00-12:00	Lunch
12:00-15:00	cont'ed
ca 15:00	airport
ca 16:00	railway station

LECTURES

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TEKES BOOSTS TECHNOLOGY

TEKES' ROLE IN THE FINNISH INNOVATION SYSTEM

Tekes, the Technology Development Centre is the main organization to implement technology policy and to finance applied and industrial R&D in Finland. Tekes´ primary objective is to promote the technological competitiveness in Finnish industry. It seeks to expand and diversify industrial production and to increase well-being in society. Tekes was founded in 1983 and is subordinate to the Finnish Ministry of Trade and Industry.

Tekes supports companies engaged in risk-bearing R&D projects with grants and loans, and finances the projects of research institutes and universities in applied technical research. Tekes launches, coordinates anf finances technology programmes that are implemented together with companies, research institutes and universities. In 1997, Tekes has more than FIM 1.5 billion (ECU 260 million) at its disposal for funding R&D in Finland.

Tekes´network of technology experts in Finland combined with the network of industrial councellors and attachés in its overseas offices provides a wide range of contacts in Finnish industry and science, as well as comprẽhensive profile of Finnish technology.

In Finland, Tekes has a significant national responsability for stimulating and coordinating international cooperation in research and technology. The most endeavours of this kind include participation in EU research programmes, the work of the European Space Agency (ESA), EUREKA projects, European Cooperation in Scientific and Technical research (COST), International Energy Agency (IEA), and Nordic cooperation. Bilateral cooperation in technology activities is also essential, in particular with the United States and Japan.

ENERGY MARKET: FROM REGULATIONS TO FINANCIAL INCENTIVES

As standard-based regulations disappear, economic incentives and sanctions have been envisaged as tools for guiding the energy market towards the desired objectives. Financial instruments of this kind include taxes and charges, on the one hand, and various subsidies, on the other. However, for example in Europe we have not reached consensus on a carbon/energy tax. Use of investment subsidies in the new energy technology market has been limited in many countries by the governments' financial problems. Research and development funding has become perhaps the most significant form of public support for energy technology.

In equipment manufacturing, engineering and consulting businesses geographical location is becoming less important. Globally operating and internationally owned companies' national identity will become weaker. Their research and manufacturing activities will be located in areas which offer best possibilities for creating additional value.

The Finnish Government is determined to create such environment for technology companies that their will maintain and strengthen their activities in our country. Therefore, a decision was made in September, 1996 to increase government research funding with a view to raising the national research input to 2.9 per cent of the gross domestic product by 1999. In addition, the Government has considered it important to guarantee the level of central university resources by means of a specific act up to 2000.

Under the decision, the government research input will be increased between this year and 1999 by 500 million marks a year. Thus the total increase over three years will be 1.5 million marks. This means an increase of one fourth from the research appropriations in the 1997 budget proposal.

From a good international average, Finland's relative research input will rise near the world top. According to OECD statistics, only Japan and Sweden have so far invested 2.9 per cent or more of their gross domestic product or more research and development.

The general aim in the development of research funding is to intensify the functioning of the whole national innovation system in order to improve its quality and impact. A special aim of the increase in research resources is to intensify the operation of the innovation system to the benefit of the economy as a whole, enterprises and employment. One important means to this end is carefully targeted, but not too narrow, allocation of financing.

Table 1. R&D expenditure in selected OECD countries as percentages of GDP in 1995.

	Business enterprise sector	Public sector	Higher education sector	National total
United States	1.75	0.25	0.4	2.45
Japan	1.9	0.25	0.6	2.9 *
Germany	1.5	0.35	0.45	2.3
France	1.5	0.5	0.4	2.4
Great Britain	1.45	0.3	0.4	2.2
Italy	0.65	0.25	0.25	1.15
Canada	0.9	0.25	0.35	1.55
Holland	1.0	0.35	0.5	1.85
Spain	0.45	0.2	0.25	0.9
Sweden	2.3	0.15	0.8	3.25 **
Australia	0.7	0.45	0.4	1.6
Switzerland	1.9	0.1	0.7	2.7
Belgium	1.1	0.1	0.45	1.65
Austria	..	..	..	1.5
Finland	1.5	0.4	0.45	2.35
Denmark	1.05	0.3	0.4	1.8
Norway	1.05	0.35	0.55	1.95 **
OECD	1.45	0.3	0.4	2.15
EU	1.2	0.3	0.4	1.9
Nordic countries	1.55	0.3	0.6	2.45

* National (over)estimate.

** The figures for both Sweden and Norway are from 1993.

TEKES EXPENDITURE ON ENERGY RESEARCH

The Tekes energy technology research programmes were launched in 1993. The aim is to produce innovative solutions that are efficient, environmentally sound and widely - even globally - applicable.

Since the liberation of world trade is affecting the energy market too, Finnish research must be able to anticipate the needs of the market and outline the areas in which Finnish companies have the best success potential. Finnish energy technology cannot be protected or given priority in any way. The need for international action to reduce environmental damage further emphasizes the global aspect.

Internationalization has proceeded perhaps even more rapidly and intensively than was anticipated a few years ago. This has been allowed for in energy technology research programmes by focusing more on the industrial applicability of research and on supporting industrial competitiveness. In balancing the new challenges, internationalization - particularly Finnish membership of the EU - has offered scientists opportunities for improving their competence through cooperation.

The scientists involved in these Tekes energy technology research programmes are taking part in several international ventures through projects managed by the EU and the IEA, the energy body of the OECD. The funding criteria for these activities are in the main the same as for domestic projects. The aim of IEA cooperation is to bring added value to Finnish energy research through technology transfer and cooperation between scientists. Finland is participating in 15 IEA programmes through Tekes programmes.

Certain projects in the EU Joule II programme have links with national programmes. In the Joule-Thermie programme, a number of research and demonstration projects whose results will also be passed on to Finnish parties have also been launched since 1995.

Today, Tekes manages a total of 12 energy technology research programmes. Their total funding for 1993-1998 is FIM 1.5 billion. About half of this is coming from Tekes, with the companies participating in the programmes providing a significant portion of the remainder. Tekes is running about 50 technology programmes in all.

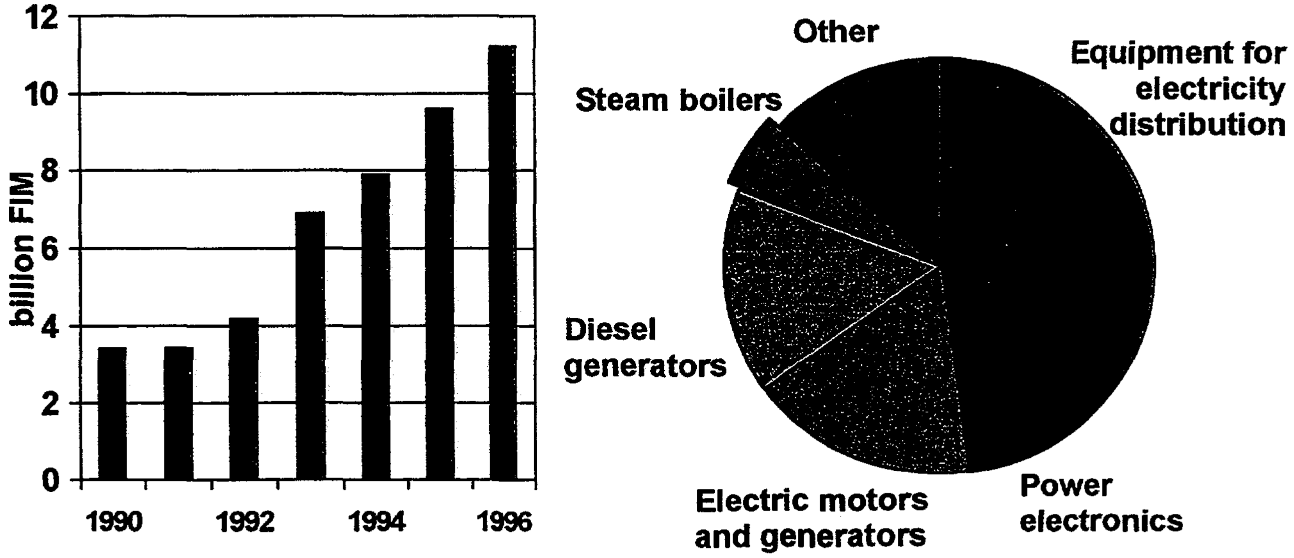

Figure 1. Exports of Finnish energy technology has increased by almost 20 per cent annually.

EXAMPLES OF THE RESULTS OF RENEWABLE ENERGY RELATED RESEARCH PROGRAMMES

Bioenergy

The aim of the BIOENERGIA research programme is to increase the use of economically feasible and environmentally sound use of bioenergy by improving the competitiveness of existing peat and wood fuels. Research and development projects will also develop new economically competitive biomass-based fuels as well as new equipment and methods for make possible the use of economically profitable and environmentally sound bioenergy.

As a result, several promising new technologies are available for more cost-effective procurement of fuel wood have been demonstrated. Methods have been developed and demonstrated for integrated production of industrial raw material and wood fuel. Peat can be produced in a more efficient and environmentally acceptable manner. Improved biomass handling , e.g. drying technology is available on the power plant scale. Equipment for pressurised biomass feeding has been developed. Concept for production of pyrolysis oil is close to demonstration

Advanced energy systems and technologies

The aim of the NEMO 2 programme is to promote the development of Finnish technology related to novel energy systems, to promote technology exports and to incease the utilization of wind and solar energy in Finland.

As a result, In terms of aims the main result is the programme's positive impact on business. During the programme the volume of business activity in the sector has grown to FIM 200 million per annum, of which more than 80 per cent is exports. The strong growth of advanced energy technologies is a result of the development of top-level technology, favourable trends in international markets, availability of venture capital and related publicity directed to Finnish target groups.

Small scale wood combustion

A new programme called TULISIJA ("fireplace") was launced in 1997. In the programme, companies (mostly SMEs) work together with research institutes in order to decrease emissions from small fireplaces. Another objective is to enhance fuel economy of small scale wood combusion.

OPET

The OPET (Organisations for the Promotion of Energy Technologies) Network aims to promote the wider use of new and innovative energy technologies, within the general context of the EU energy and RTD policies. Thirty nine OPETs exist in all the EU Member States and associated countries such as Liechstenstein, Iceland and Norway. OPET Finland is hosted by Tekes.

The activities of the OPET Network will help its clients make decisions about reducing energy consumption of non-sustainable energies by identifying appropriate technologies which conform to their needs. These clients include industry, utility and financial representatives together with technology manufacturers and developers, and the public sector. By directly addressing the needs of their clients, OPETs provide an effective means of information exchange for these various groups often facilitating investment. The Network members similarly work closely with national and international energy programmes as well as with the European Commission and its programmes.

The OPET undertake are wide range of activities such as specialised technical seminars, major exhibitions, technology trainings, articles and sectoral and technical market evaluations. OPET activities emerge from a continuous dialogue with the market actors and closely reflect the needs for identified technologies. Each OPET carries out a set of activities at local, regional and national levels, in the most relevant economic sectors. Further added value is provided through the active relationship between OPETs in different Member States. All OPET are staffed with knowledgeable experts in the field of energy technology and are available to advise both suppliers and buyers. They provide information about innovative energy technologies as well as about means of support from European Union programmes.

The European Commission supports the OPET Network as a collaborative effort between the INNOVATION Programme (DGXIII) and the Demonstration component of the JOULE-THERMIE Programme (DGXVII) under the Fourth Framework Programme. The Demonstration component of the JOULE-THERMIE programme supports the demonstration, dissemination and promotion of innovative energy technologies. The INNOVATION programme aims to disseminate, optimise and exploit the results of RTD and demonstration activities, and has as one of its main objectives, the stimulation of an unrestricted diffusion of technologies and knowledge in Europe.

Renewable Energy in Latvia

Prof.,Dr.habil.Sc.ing. Peteris Shipkovs
Dr.Sc.ing. Galina Kashkarova
Latvian Energy Agency
M.Sc. Maris Shipkovs
Energy-R Ltd.

To facilitate the recovery of economy of Latvia comprehensive work must be done to develop infrastructures, among which energy is highly significant. Energy sector has been one of the most important priorities since reestablishment of independence of Latvia.

Latvia is among those countries that do not have gas, coal and, for the time being, also oil resources of its own. The amount of electric energy produced in Latvia does not meet the demand, consequently part of power has to be purchased from the neighboring countries. Firewood, peat, and hydroresources are the only significant domestic energy resources. Massive decrease of energy consumption has been observed since Latvia regained independence.

Domestic and renewable energy resources have been examined and estimated. There are already 13 modern technology boiler houses operating in Latvia with total installed capacity 45 MW that are fired with wood chips. Latvian companies are involved in the production of equipment. 7 small HPPs have been renewed with the installed capacity 1,85 MW. Wind plant in Ainaži has started its operation, where two modern wind turbines with the capacity 0,6 MW each have been installed.
Mechanism of tariff setting is aligned. Favorable power energy purchasing prices are set for renewable energy sources and small cogeneration plants.

Small hydroenergy

Use of small hydropower plants and mills in Latvia is a tradition with long history. The oldest hydropower plant in Latvia is Smiltene HPP which was erected in 1905 on the river Abuls. In 1926 there were alredy 26 HPPs with total capacity 1 MW. Intensive construction of small HPPs was going on after the World War II: in 1949 there were 60 small HPPs operating in Latvia, i.e. 19 HPPs and 41 water - mill with total installed capacity 5,8 MW were constructed. In various periods of time about 200-700 water-mills were operating in Latvia. At the beginning of the fifties about 520 water running. About 300 of this number produced electric energy, with capacity of installed turbines 10 MW and capacity of generators 2,34 MW. From 1954 until 1997 operation of all small HPPs in Latvia was stopped. About water-mills continued functioning.

In the fifties the institute "Laukuprojekts" developed uniform river scheme in the view of possible small HPP construction for rural demand side. The scheme included practically all small and medium rivers in Latvia, it was planned to construct 533 new HPPs with installed capacity 159,9 MW (excluding the Daugava) and annual power generation of about 500 mill. kWh. After 1950s considerable land-reclamation work was done, so it is reasonable to work out a new conception for development of small hydroenergy, which would reestimate the existing and prospective hydropower plan potential.
Some capsule-like microturbines utilizing energy of river streams were used years ago. Such turbines with capacity 5 ÷100 kW are expected to be used quite actively also nowadays.
Since beginning of the nineties intensive reconstruction of small HPPs and mills has been started. Several companies are set up for this purpose - joint-stock company ABULS, SIA LATGALES ENERĢĒTIKA and others. VEF Reconstruction and Maintenance Center deals with rehabilitation of old turbines, together with joint-stock company ABULS production of new Francis type hydroturbines has become feasible. RIGA ELEKTROMACHINERY PLANT produces elektrogenerators for small hydroplants.
Power produced by reconstructed small HPPs in 1995:

Brutuļi HPP (0,05 MW) .... 0,068 MWh
Brenguži HPP (0,13 MW) .... 0.450 MWh
Trikāta HPP (0,045 MW) .... 0,147 MWh
Feliciānova HPP (0,6 MW) .... 1,061 MWh
Viļāni HPP (0,6 MW) .... 1,218 MWh
Jeiska mill HPP (0,022 MW).............0,003 MWh
Aiviekste (0,4 MW) ....1,500 MWh

Total installed capacity of small HPPs - 1847 MWh, generation in 1995 - 4,447 MWh.

USE OF SOLAR ENERGY

In some places in Latvia solar energy is used for drying agricultural products (hay, grain, etc.) by installing collectors of dark polyethylene pipes above drying equipment. One can find similar amateur made equipment for water heating. As experience of Nordic countries proves it is possible to use successfully solar energy for water heating. Investigation in this area should be carried out. The sun radiation level in Latvia which can be possible to utilize is about 1700-1900 hours per year. Number of clear days is about 30-40 per year. In summer period sun radiation up to 500 kcal/m^{2}h per day and in winter and autumn period is about 300 kcal/m^{2}h.
Solar collectors have not found noteworthy application in Latvia yet. Some theoretical and experimental research was initiated with an aim to develop a theoretical conception of solar collectors, of their being appropriate for the climate of Latvia, and to provide real constructive solutions. Yet, it is possible to approach the optimum power supply variant using the combined heat supply that

envisages the utilization of solar and wind energy in combination with other sources of energy.

WIND ENERGY

Windmills have been operating in Latvia since ancient times. Before the World War II also wind generators were manufactured and used. Afterwards all equipment of this type was either dismantled or deteriorated. From the beginning of the nineties wind energy has been restored based on international know-how and technologies in this field.

Wind cadastre was elaborated in Latvia. The strongest wind zones are at the Baltic Sea and in the eastern part of Riga Bay. Hence, optimal conditions for wind generator installation is on the Baltic Sea coast from Pāvilosta 70 km inland and in the eastern part of Riga Bay as far as Ainaži 10 km inland. This territory is about 10600 square kilometers large, and all type wind generators can be installed here at the height 30 ÷ 50 m. According to experts, by installing in this zone averagely on each 100 square kilometers up to 1 MW capacity it is possible to produce up to 600 mill. kWh power energy.

Deeper inland good potential for wind energy is in the environs of Riga, Bauska, Rēzekne, Saldus, Cēsis and Dagda, as well as in western windy sides of Kurzeme, Vidzeme and Latgale highlands. Wind generators to be installed deeper inland must be appropriate for wind speed 5,6 ÷ 6,2 m/s. Wind zone with limited generator installation potential is around Skulte, Zvejniekciems, Dobele, Alūksne, Viļaka, Stende, Gaujiena, Auce, Skrīveri and Gulbene, here wind speed is low - 4,6 ÷ 5,4 m/s.

Unfavourable conditions for wind generator installation is around Jūrmala and in lee side zones of Kurzeme, Vidzeme and Latgale highlands. Here wind speed is 3,8 ÷4,2 m/s. If standard wind generators are installed in this zone, it is possible to obtain only 10% of the energy produced by the installed capacity wind generator under optimal conditions.

Special attention should be paid to main migration roads and nesting sites of birds.

Now there are 12 wind parks in Latvia with total capacity 1,333 MW. The biggest is Ainaži wind park, where 2 modern turbines with capacity 0,6 MW each are installed. In 1995 total power production in wind parks was 0,464 MWh.

Company AISMA together with leading Danish companies has started wind generator production (10 ÷270 kW). Firm BALTARUTA produces portable low capacity wind generators (0,5 kW). There are some other wind generator design projects.

GEOTHERMAL ENERGY

Development of geothermal energy or underground rock and water heat energy in Latvia could be started in the coming years. Results of geological exploration testify that in the central and southwestern part of Latvia there are geothermal anomalies where the temperature of rock and underground water in the depth of 1300 -1950 m is 30 -65°C.

Thermal water of such temperature is classified as low potential water, nevertheless it is possible to use such water as a source of heat for heating and balneological purposes. Underground water with even lower temperature (10 - 30°C) can be used in pisciculture when fish breeding farms are established and necessary conditions for fish rearing also in winter are secured. Latvia has a long-term experience in using geothermal water in pisciculture. Common geothermal heat production scheme contains absorption heatpumps and two wells that are bored at a certain distance from each other. Underground water of high temperature is pumped from one well to the heat exchanger of heat pump where it looses part of heat energy. The other well is for injection of cooled water back into this aquifer. Usually thermal water is of high salinity, therefore it is not possible to inject it in open water basins. Such backinjection provides constant pressure in the utilized aquifer and resolves environmental issues.

Previous calculations on use of thermal underground water resources prove that capacity of heat sources that operate on geothermal energy could be up to 175 MW. Latvia geothermal data base has been created by means of Danish financial support. Currently first experimental projects for geothermal heat plants in Dobele and Liepāja are under development.

Firewood

Biomass of firewood occupies the most important place among domestic energy resources. The amount of firewood production in the forests of Latvia was 6,9 mill.m^3 in 1995.

The Parliament of Latvia has approved 8,35 mill.m^3 of firewood production in the coming years. It is quite real to increase firewood production in private forests. According to experts, resources of forests in Latvia allow to increase firewood production without damage to nature up to 10,5 mill.m^3 a year.

Several international projects are developed in Latvia analyzing forestry resources and amount of energy worthy wood, these projects differ ass to their results. It is fairly reasonable to assume, if the wood felling volume is 8,35mill m^3, energyworthy wood will be 4,35 mill.m^3. 1,5 mill.m^3 of this amount is processed into firewood by centralized means.

Resources of energyworthy wood in Latvia are analyzed. Conversion of the existing boiler houses into energyworthy wood fired ones takes place following these data. The most common form of energyworthy wood is either firewood or woodchips. In 1993 - 1995 about 240 new or reconstructed wood fired boilers are installed (with installed capacity more than 250 MW). According to experts, in the nearest future this number could increase for about 300, especially in small towns and rural areas.

Introduction of modern technologies in Latvia for heat production from wood was favored by international programs financially supported by the governments of

Denmark and Sweden (NUTEK). Within the framework of these programs the following woodchip fired boiler houses are either reconstructed or constructed in Mālpils - 4MW, Balvi - 2,4 MW, Alūksne - 5MW, Jāņmuiža (region of Cēsis) - 3 MW, Slampe - 3MW, Rūjiena - 1,5 MW, Gulbene - 4,5 MW, Dubulti (in Jurmala) - 7 MW, Rauna - 1,5 MW, Jēkabpils - 1,5 MW, Viesīte - 1,4 MW and Daugavgrīva (in Riga) - 7 MW. Recently also Latvian boiler and equipment manufacturers have been involved in the implementation of programs, which promote higher technical quality of domestic products.

SIA KILBE prepares woodchip and exports it (to Sweden). In1995 export was 210 th. m^3. Wood for this woodchip mainly comes from the region of Cēsis, sawmills included. Humidity rate of exported woodchip is up to 45%.

One of the fuel types that is produced from woodwaste is woodwaste bricks. They are produced by various firms. Part of bricks is Exported (to Denmark and other countries).

Production of charcoal is one of the ways how to utilize woodwaste. Charcoal is very popular in the European and the Near East markets and it is exported. It is traded also in Latvia, one can buy a package of charcoal mainly in petrol filling stations. Currently Wood Chemistry Institute is involved in development of technological process for production of active charcoal. There are sufficient resources of raw material in Latvia, which suffice production of about10÷20 th. tons of charcoal a year. At this stage a lot of small firms are involved in this business, 40 of them are united in the Association of charcoal producers.

Production of wood granules has been started on a small scale.

Peat

In Latvia peat is found in approximately 5700 bogs of total area 640 th. ha, which occupy about 10% of the whole territory of Latvia. 11 enterprises and several private firms are involved in peat extraction. All in all they operate in peatbogs of more than 10 th. area. About 1800 ha of this number is used for extraction of milled peat for heating. Some territory is used for production of moss peat and chunk peat. Peat bricks are produced in Rezekne unit of state joint-stock company STRUŽĀNI PEAT FACTORY, with annual capacity 50 th.t a year. To continue production of the same amount of peat bricks in the coming 10 - 15 years it is necessary to develop a new peat-field with 100^{th}. t of peat bricks a year and upgrade production equipment. Total energyworthy peat resources in Latvia are:

existing - 613 mill. m^3, or 94 mill. t;

prospective - 226 mill. m^3, or 35 mill. t.

Production of peat in 1995: milled peat - 294,6 th. t, peat bricks - 25,6 th. t, chunk peat - 25,9 th. t. Major consumer of milled peat is Riga CHP-1 which consumed 270 th. t during heating seasons of 1994/1995. District boiler houses consume approximately 80 - 100 th. t a year.

Peat production enterprises are united in Latvian peat producers association. To extend use of peat in energy, construction of new boiler houses and

cogeneration plants, conversion of the existing boiler houses, and upgrading of the old peat production and processing equipment is being tackled.
SIA SECES KŪDRA has concluded lease contracts with local authorities concerning conversion and operation of specific boiler houses (third party financing). Such boiler houses are alrady operating in Laubere, Ērgļi (2 units), Alūksne (2 units), Skrīveri and Kārsava.
State-of-the-art in peat industry and calculation based recommendations on possible use of peat resources and efficiency in energy will be provided by research carried out in the framework of the PHARE program of the EU.

BIOGAS, BIOMASS

Products of photosynthesis, i.e. plant biomass which is formed every year in fields and forests have great potential. These places are natural photosynthesis systems that are constantly cumulating solar energy. This energy is sometimes called bioenergy. Use of bioenergy is exceptionally significant in such a country like Latvia, where there are scanty domestic energy resources.
Separate chapter deals with use of firewood and peat. It should be pointed out that due attention has not been paid until now in Latvia to cultivation of rapid-growing tree plantations for energy industry purposes. It is possible to have such plantations as there are areas of unused land in Latvia. Within some years when full cycle of wood waste usage is mastered, it could be topical to have rapid-growing tree plantations for wood biomass.
Rape oil can be produced and used as a substitute for diesel fuel. On international scale this issue has been resolved theoretically and technically. Working group that deals with use of biogas and biomass at Ministry of Agriculture has calculated if 15% of arable land in Latvia were used for rape cultivation and if oil presses were installed in farmsteads (small units and factories) it would result in annual production of 240 th. t diesel fuel substitute for competitive primary cost. The same process produces fodder additive of high value containing protein, oil and vitamins, as well as glycerin. European standard pilot equipment for this technology could be installed in the village of Gailīņi, Bauska region using the existing experimental equipment.
In the nearest future production of bioethanol (spirit) from grain, potatoes and sugar-beets can be started as agricultural production branch. Production of spirit can be increased by 4 mill. decalitres upgrading the existing spirit production units. It would be sufficient to have 650 th. t of petrol with 5% ethanol content in the year 2005. Thus not only farmers will have guaranteed purchases in a limited market, but it will be also environmentally friendly solution, because of improved content of emissions. If petrol prices rise, ethanol produced from grain could become competitive.
There is certain experience of biogas production and use in Latvia. There are biogas units in some dairies, but the biggest unit is in Riga sewage biological purification enterprise in Bolderāja. Biogas is used for heat production.

Biogas can be obtained from organic mass in garbage dumping grounds of cities.
Agricultural, industrial as well as household garbage can be used as energy source in Latvia, furthermore, energy and ecological issues form a uniform complex. To cover these issues National biofuel program is being developed.

RURAL RENEWABLE ENERGY (PROSPECTS) IN ESTONIA

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ABSTRACT

Total potential share of renewables (biomass, wind, hydropower and solar) in Estonia is 35%. Total real share (wood, woodchips) of renewables is ~4.5% (1995) only. The constrains and prospects of the development are discussed. The attention is focused on rural conditions.

1. INTRODUCTION

The economical and political situation in Estonia is even today highly influenced from the Soviet period.

Soviet period was characterized by large-scale industry and agriculture oriented 90% to the domestic market of the USSR, intensive immigration and urbanisation, and unlimited energy supply till 1985., produced on the oil shale based electricity was (about 40% from the total production) a traditional export article to the Russian Federation and Latvia. The electrification level in Estonia was high: about 95% of the households were connected to the grid. In 1960-85 the rural population moved to the centers of collective-farm where urban type residential houses were prevailing and small scale district heating systems were developed while energy saving building standards were neglected since the energy price was low.

Regaining of independence of Estonia in 1991 was followed with the collapse of large industry both in towns and in the countryside. Trying gain upper hand, Russia implements measures reminding economic blockade, which have resulted in the reduction of export to Russia to 17%. The major economic partners of Estonia are mainly in the Western countries today and although the reorientation has not been very painful, the GDP of Estonia is still an order lower than that of the Western partners[2] . The relationship between the GDP and "clean" energy supply is evident and due to its visible price the renewable energy has difficulties to be implemented. The large industry replaced by diversified small business, the large agricultural farms are presently in the stage of privatisation and unemployment is especially high in the countryside. The foreign investments and intensity of economic activities is distributed unevenly over the territory of the country while the situation is the worst in South-East Estonia. With the disintegration of large agricultural

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[2] In US $ - DK: 26730; S: 24700; D: 23560; FIN: 19300; **EST: 3080 (1200?)**; RU: 2340

farms the centres of former collective farms become smaller and thus the heat load reduces there, small family farms are restored outside the former centres and thus the electrification level in Estonia is objectively also decreasing.

Thus, with disregarding the economic constraints, the prerequisite for the development of renewables are existing in the countryside.

To sum up the above, the main problem in rural settlements (in the present meaning too large) is 1) mainentance of (overdimensioned) district heating systems and 2) with the development of new family farms their electricity supply.

Thereby it should be estimated whether the PV electricity can satisfy the technological demand of a farm or the only practicable solution is extension of the electrical network.

In addition the large number of gardening co-operatives and summer cottages should be considered as a potential renewable energy market.

2. ENERGY SUPPLY IN ESTONIA

The energy demand of Estonia has decreased due the production reduction in 1988-93, but since that time some stabilisation is observed (Fig. 1). The domestic (mainly oil shale based) energy (electricity) covers 55-62% of the energy balance. In electricity production the generating overcapacity makes about 40%, i.e. the power plants are underloaded and thus the efficiency is low. At the same time the equipment and technology of power plants is obsolete with the operation resource of about 10-15 years for the *Balti Power Plant* and 15-25 years for the *Eesti Power Plant*. Neither of them can be closed or transferred to stand-by regime for the future due to social reasons. The high voltage transmission lines are well developed, but without sufficient repair for a long time and thus investments in the electrical sector are inevitable. In the rural areas the low voltage networks are relatively in a bad condition and their restructuring is necessary.

The share of conventional renewables increased to 8.3% in 1995, but it includes also peat since peat and wood are not given separately in the Estonian statistical database. According to indirect estimations this 8.3% is distributed as shown in the Fig. 2 and almost used for heat production. Approximately half of produced peat is processed into peat briquette and one third of the produced briquette is exported.

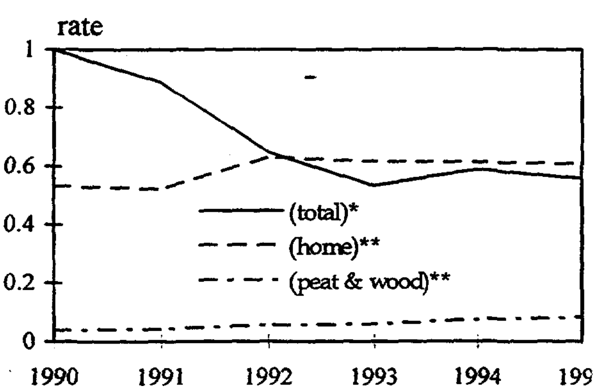

Fig. 1. Estonian fuels demand evolution
* - rate to the capacity in 1990.
** - rate to the current capacity.

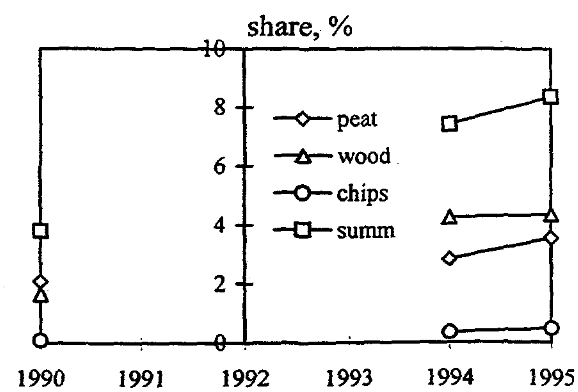

Fig. 2. Share of wood products in the "wood & peat" demand (sum).

To sum up the above, the heating problems of the rural area should be considered one of the most acute problems to be solved.

3. THE RESOURCE OF BIOENERGY AND ITS UTILIZATION

Wood. It is difficult to trace in the Estonian statistical records what is the share of various domestic solid energy carriers consumed in the rural areas. But there exists any reason to assume that the most of wood is consumed namely in the country while peat and peat briquette is evidently mainly consumed in towns.. There is no data available on the distribution of boilers between rural areas and towns. The data available according to production branches is not reliable since heat producers in the countryside are not totally producing only for agriculture.
To the end of 1995:

172 peat fired boilers with the capacity of 301 MW and the energy output of 319 GWh;

908 wood (chips) fired boilers with the capacity 1,065 MW and the energy output of 874 GWh were in operation.

The boilers have different origin. The most wide-spread are the Russian, Estonian, Swedish and Danish made boilers (with prefurnaces). When speaking only about wood (and peat) fired boilers, most of the furnaces are equipped with fixed or movable grates. First boilers with fluidized bed furnaces have been built. The wood and peat gas generators are practically unknown in Estonia. About 10 Estonian (inc. Estonian-Swedish and Estonian-Finnish joint) companies are active in boiler building.

The Estonian wood resource is essential: 47% of the Estonian territory is covered with forests, the total growing stock of stands is 294.4 Million solid meter (s/m) and the felling outturn in1995 was 3.8 Ms/m, i.e. 1.3% from the total growing stock. It means that the natural increment exceeds the felling outturn and according to the forest specialists the felling outturn could be increased up to 7.8 Ms/m. That is why the forest specialists are rather skeptical about the idea of introducing energy forests (presently 5 experimental sites). The map in Fig. 3 shows the distribution of cutting. Thus the wood based heat production has potentials for the development in Estonia, which can be seen in Fig.2, but the wood fired boilers built in 1992-1994 with the support of foreign loans and international consultants have not reached the designed economical efficiency and presently even some re-conversion to burning heavy fuel oil can be observed.

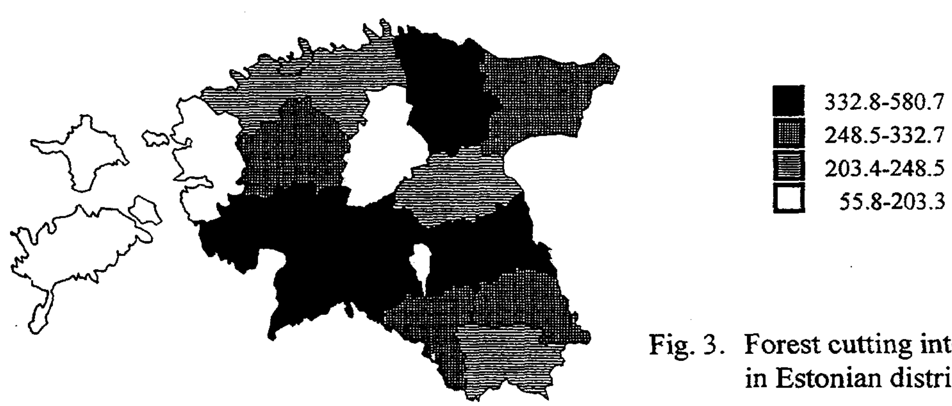

Fig. 3. Forest cutting intensiviness (10^3 s/m) in Estonian districts

The problem here is practically a 100% non-utilization of wood waste from the cutting areas (expensive equipment and high transport cost). But the wood waste from saw and timber industry is utilized practically for 100%.
It can be stated for the conclusion that the energy resource of the solid biomass in Estonia reaches the capacity of 12-13 PJ.

Solid waste energy. The calorific value of the municipal waste investigated in Estonia is 6.5 MJ/kg at the specific density 0.22-0.4 t/(s/m). The total heat capacity of the municipal solid waste in Estonia makes 6 PJ per year, but it is not utilized and hardly will be utilized in the visible future. But the landfill gas (mainly methane) from the Pääsküla landfill with the resource of 18 GWh (1995) is already captured and utilized. No other landfills with the capacity of industrial importance are available in Estonia.

Animal manure. The potential of the animal manure is estimated 4 PJ per year, but it is utilised in practice only in the *Pärnu Seavabrik Ltd* and *Linnamäe Peekon Ltd* (two large pig farms). The data on energy yield and the process efficiency is not available.

Straw.The potential energy capacity is estimated 1.2 PJ per year, it has not been utilized up to now since a special furnace and a monocultural crop growing area is required for making the business economical.

4. THE WIND ENERGY RESOURCE AND ITS UTILIZATION

The wind energy development is focused on electricity generation in the areas where the annual average wind speed exceeds 5 m/s. In Estonia geographically favorable sites are the western coast and islands making in total 16.5% of the territory. But in these regions the populated areas are scarce and the electrical networks are not sufficiently developed. The formal wind energy potential in these regions makes 18 PJ and thus exceeds even the potential of biomass. In the mainland with the high percentage of forested area (~60% of the territory) the annual average wind speed remains under 4 m/s and thus cannot harnessed beneficially. Presently we cannot speak about the utilization of wind energy in Estonia on the professional level: a single 150 kW *Danwin* wind turbine installed at Kõrgesaare in 1995 has not been started up to now (for subjective reasons). The Estonian energy specialists show negative attitude towards the wind energy development opposite to the unjustified optimism-of the Estonian greens. A positive trend in this field is the Estonian Wind Atlas compiled by A. Kull as his (magister) diploma work in Tartu University, but it has not been published yet being therefore unavailable to the wider circle of specialists.

5. HYDROPOWER

For political reasons, the hydropower resource of the River Narva (with the peak load of 100-150 MW) is not available for Estonia. Due to flat relief, low situated and small area, the total hydropower potential of Estonian rivers is rather limited. Different estimations have been made. According to:

A. Velner (1922)- 58.8 MW; A. Velner and K. Hommik (1936)- 82 MW; S. V. Grigorjev (1946)- 48 MW; T. Eipre (1949)- 18.6 MW; A. Kaldamäe (1991)- 7.3 MW, which seems to be underestimated as a theoretical potential.
The total capacity of hydroturbines in Estonian Republic in 1936. was 25 MW, including 9.34 MW used for electricity generation. Evidently the power equipment installed on the River Narva is also included in these numbers since the River Narva was an Estonian river in these times. In 1940 the total installed capacity of the hydroturbines was 36.8 MW.

During the war most of hydropower turbines were destroyed, but in 1945-50 some plants were restored. So in 1949 43 small hydropower plants with the total capacity 1.14 MW were working in Estonia. With the further development of oil shale based large-scale power engineering in sixties practically all the HP plants were closed in Estonia. An exception is Keila-Joa 200 kW Hydropower Plant, which was never been stopped or switched to the autonomous operational regime. Private business (*Generator Ltd*) has shown interest in hydroenergy based electricity production. Some old demolished hydropower plants have been restored since building new ones demands major capital investments (1000-3000 $/kW).

Table 1

Name	River	Capacity kW	Estimated capacity kW	Pressure m	Turbine type	Output MWh
Põltsamaa	Põltsamaa	60*	+40	2	Propeller	250
Keila-Joa	Keila	200		4.5	Francis	650
Saesaare	Ahja	200		9	Francis	1360
Leevaku	Võhandu	120		2.5	Kaplan	700
Kotka	Valgejõgi	180		6.6	Propeller	600
Tudu	Rannapungerja		50	5.0		
Kunda	Kunda		400	9.5		
Joaveski	Loobu		100	3.5		
Nõmmeveski	Valgejõe		120	7.8		
Linnamäe	Jägala		400 (2000?)	8.0		
Jägala	Jägala		650	17.0		
Tammiku	Jägala		100	2.5		
Saunja	Jägala		125	3.2		
Lilli	Jägala		60	3.5		
Kehra	Jägala		50	2.5		
Kaunissaare	Jägala		100	3.0		
Kohila	Keila		75	2.5		
Kamari	Põltsamaa		*400*	5.0		
Vaimastvere	Pedja		50	3.5		
Painküla	Pedja		65	4.0		
Härjanurme	Pedja		100	5.0		
Tõrve	Pedja		70	4.0		
Räpina	Võhandu		*100*	100		
Sindi	Pärnu		500	3.2		
Jändja	Pärnu		100	2.5		
Suurejõe	Pärnu		150	2.4		
Summary		800	3605			3560

* not connected to the grid.

Table 1 gives an overview on the working hydropower plants and potentially prospective restoration projects. Unfortunately, no data is available on the level of automation nor the existing water storage basins (capacity).

The total capacity of working hydropower plants and those under restoration would be 4.4 MW and here the total resource of 22 potential sites is given 2.9 MW. Thus, excluding the River Narva, the technical potential of the Estonian hydropower is ~7-7.5 MW or 0.11 PJ of energy. The present review does not cover hydropower plants with the capacity below 50 kW each. There total number could reads tens of units, but their total capacity is notsignificiant enough to make any change in the prognosis.

6. THE RESOURCE AND UTILIZATION OF SOLAR ENERGY

Resource. According to the series of observations in a 30-years period in the Tartu Observatory the annual average resource of solar energy in Estonia reaches 977 kWh/m^2 and the difference of solar radiation on Estonian territory is 10-15% being higher in the coastal region and on the West-Estonian islands. Thus, taking for the basis for the solar conversion 0.01% for the forest-free surface (i.e. 1 m^2 /ha), the potential of solar energy in Estonia is 8.4 PJ, which is a considerable value. Buth this capacity is available only in the summer and distributed unevenly even through this season. The development level of technical means today does not allow seasonal storage at acceptable cost.

Utilization of solar-thermal energy is in the initial stage in Estonia. The *Hange Ltd* (Haapsalu) is the importer of the heat-pumps an has built some heating systems based on stored in the ground solar energy. The 40 m^2 DHW system for the Vändra hospital has been built 1995 with the aid of the Nynäsham Commune (Sweden) and 6x10 m^2 auxiliary heating system in the Keila SOS-children village also built with the help of the humanitarian aid are the systems of professional level. Neither of the projects has documentation and measuring equipment included and therefore their value as a demoproject is low, which is very required to disseminate the idea to utilise solar-heat technology. The implementation of solar DHW systems has prospectives in numerous (in total ~100000) private houses, farms and summer cottages all over Estonia. Some research work on the improvement of the efficiency of these systems is carried out in Estonian Energy Research Institute. The Vätta schoolhouse (island of Saaremaa) and the guest house (to be designed) in the Karula National Park (Võrumaa) have applied for the right to be a demonstration site in case a demonstration project with the EU support is approved. Both owners could fund the projects to some extent. Unfortunately, both of the sites are located far away from the main roads in the "deep" countryside, which arise some communication problem.

Utilization of solar-PV technology has been implemented in 36 sites of the Estonian National Maritime Board (lighthouses and buoys), which were lighted by nuclear batteries in Soviet period. Each supply system consist from two 51 W (mainly the *Neste* made) PV panels, Russian made 250 Ah NiCd batteries and an electronic controller made in Estonia (Fig. 4), which makes the performance of the controller and telemechanical devices compatible. The electricity supply project to the named 36 sites is practically completed and transfer to the distant control of the marine pilot units can start. Presently no information on additional conceptions on the use of solar electricity in other business is available.

7. THE POLITICAL STATUS OF RENEWABLES AND CONCLUSIONS

As a positive shift, for the import of the wind- and hydropower equipment and on the electricity produced with thus a zero-value turnover tax to the year 2006 enacted by the Sate Assembly should be mentioned. But in connection with this problem the solar energy was forgotten and so the lobby work with the politicians must continue.

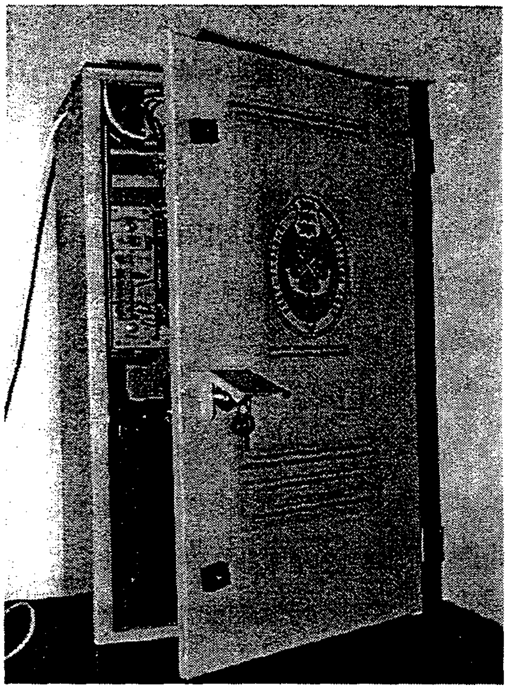

Fig. 4. The E610 local controller for PV supply, used by Estonian National Maritime Board.

Total potential share of renewables - 35%
Total real share of renewables - ~4.5% (1995)

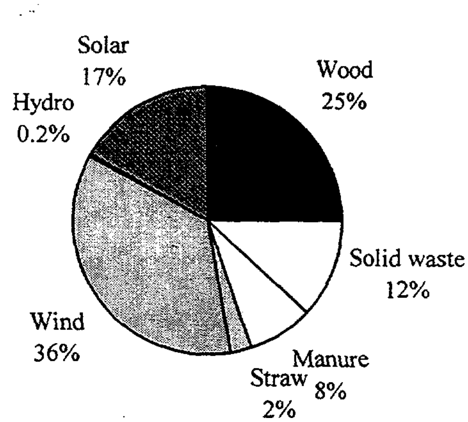

Fig. 5. Share of different renewable resources in Estonia: Hydro- technological resource, others – theoretical resource.

The conclusion on the Estonian renewable energy potential is given in Fig. 5. The realisation of the potential (52 PJ), which makes 35% from the total energy demand in Estonia in 1995 (142 PJ) does not depend on the natural limitations, but on the economic restrictions. The brightness of colors in Fig.5 shows the level of realisation prognosis.

REFERENCES

ESA. Statistical yearbook of Estonia 1996, 272 p.

E. Pajumets, T. Tomson. (1994). Estonian Renewable Energy Survey, their Utilization and Prospects. Problems of Contemporary Ecology. Proc. of Estonian VI Conference in Ecology, Tartu, pp 50-55 (in Estonian).

P. Raesaar. (1996). Estonian Hydro Energy Technology-Possibilities and Resources. En. Center "Taasen", Tallinn, 27 p. (in Estonian).

A. Paist *et.al* (1992). Possibilities to Use Biomass for Energy Production in Estonia. Tallinn, 67 p. (in Estonian).

RENEWABLE ENERGY FOR RURAL ELECTRIFICATION

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In spite of quite good centralized power supply system, rural electrification levels across Russia vary widely: in some regions there are densely populated communities which lack power, while in other regions the most pressing need is to electrify dispersed, isolated villages or homes.

The main objective of the Russian project "Renewable energy for rural electrification" is the elaboration and application of new technologies of rural electrification in order to ensure the sustainable development of unelectrified rural areas of the Russia.

The long-term objectives of the project are:

- to improve the living standards of people in rural areas, who lack centralized energy supply systems, by introducing of new system for generation, transmission and distribution of electrical energy on the base of renewable energy systems (RESs);
- to provide a reliable cost-effective electric service of electrified and unelectrified communities;
- to reduce consumption of organic fuel in electric generation systems;
- to support of our military industry in converting their activity into the renewable energy sector:
- to protect the environment.

RESs are increasingly being viewed as a favorable option for providing power to isolated villages or homes, collective or private farms, etc. Small-scale systems, including solar photovoltaics (PV) and wind turbines, are reliable and cost-competitive options for household electrification in remote, isolated communities. Renewable-based grids can be also an increasingly attractive alternative for rural electrification plans because many of local grids are not reliable. Technology options include micro- and mini-hydroelectric plants, biomass-powered generators, small geothermal, PV, solar thermal, wind turbines, and hybrid systems which may be connected to the electric grid.

The centralized utility grid extension is not a realistic method of delivering energy services to rural populations in many parts of the Russia, and RESs offer a reliable, sustainable, affordable alternative. Renewable energy technologies are proven and market ready.

To achieve the goals the project foresees the following programme of activities:

- strategy of development and utilization of renewable energy for rural electrification.
- work out and apply in electric utilities improved monitoring system with grid connected renewable-based power plant, day-night tariff counters, special schemes of electric back-up system, certification of electrical equipment and tools.
- develop new system of electric energy transmission and single-wire zero resistance losses renewable-based electric grid.
- elaborate new high efficiency straight flow microhydro power station, including new turbine blades configuration placed inside the synchronous generator rotor with permanent magnets.
- design and construct stand alone hybrid energy systems, including microhydro-wind-solar biomass and diesel electric power plants:
- design and construct the high efficient solar-fuel power plant with new type of steam turbine with external thermal power supply, solar-biomass cogeneration facility with new screw steam Stirling cycle machine, and high efficiency environmentally benign modular wind generator for farmer's dwelling.

Application of renewable energy system for arid and recreation zones.

Following results will be achieved with regards to the main project objectives:

Contribution to the rise in living standards of rural population by implementation of modern renewable energy technologies. New technologies of rural electrification and utilization of renewable energy in electric energy systems will be elaborated, efficiency of currently used technologies will be improved. A number of electrical power engineering systems on the base of various renewable energy sources will be designed and manufactured.

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TECHNO-ECONOMICAL ANALYSIS

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1. SUMMARY

The present energy situation in the target area can is summarised below:

- 20 mill. without electricity in north-west Russia
- 50% of people in the Baltic's without electricity
- very high technical skills
- biggest problem is the finance

Based on the short analysis shown below and our experience with the Baltics and Russia, the following important points on rural renewable energy utilisation's and applications in these regions may be put forward:

Energy situation:
- the energy systems are ineffective
- energy conservation is often the first measure that should be done
- the local energy production system is often oversized
- the price of energy is below the EU market price
- the economic situation of utilities and customers is often poor
- fuelwood is the main local rural renewable source in use

Advantage for renewables:
- the rural area and population without urban energy services is relatively large
- the authorities have a positive attitude for renewable energy sources
- the local environmental problems may be very severe
- renewable energy is in practice the only available local energy source
- use of local renewables may save currency and increase local involvement
- local energy centres may disseminate information
- private investors and end-users may have commercial interests
- local industries interested in the business possibilities

Restrictions:
- the financial questions is the most critical factor
- the awareness of renewables is not in general good
- demonstration and pilot plants are needed prior to mass markets
- logistics still often poor

Examples for possible technical solutions:
- summertime hot water production with solar collectors
- small-scale solar district heating to enable shut down cut of the boiler plants
- local self-building of solar collectors
- solar heating for social buildings (e.g. hospitals, elder homes etc.)
- PV electrification (e.g. lighting, communication) of isolated areas
- PV in agriculture (e.g. fence systems, pumping)

- PV for resorts (e.g. remote touristic sites)
- woodfuel heating systems on variable size (single house - village)

- fuel conversion of boilers from fossil fuel to woodfuel
- combined solar heating and woodfuel systems
- woodfuel heating for agriculture and food production (e.g. greenhouses)

PRACTICAL EXPERIENCES OF SMALL-SCALE HEAT GENERATION FROM FUELWOOD IN FINLAND´S RURAL AREAS

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Summary

Heating entrepreneurship is a new form of rural entrepreneurship in Finland. The action model is such that the entrepreneur mainly carry the responsibility for looking after heating of municipal real estates using fuelwood. The heating entrepreneur procures the fuel and carries out the heating and supervision work in the heating plant. The entrepreneur is paid for services rendered on the basis of the amount of heat generated. The price of heat is usually bound to the price of fuel oil. There are thirty to forty functioning site where heating entrepreneurship is practised in Finland and several new sites are being planned.

The heating entrepreneurship offers extra income especially to farmers who have otherwise unmarketable potential fuelwood in their woodlots, under-utilised timber harvesting equipment, experience of heating using wood chips, and lack of job opportunities. However, heating entrepreneurship can seldom provide the primary livelihood.

When choosing the form of heating entrepreneurship, the factors to be taken into account include the size of the site to be heated and the required investments. The commonest form is one in which 1-3 entrepreneurs are responsible for heating local premises. In such cases the size of the heating plants is usually 50-500 kW. Heating entrepreneurs are usually forest-owning farmers. In small heating sites managed by heating entrepreneurs, the main fuel is usually wood chips made from small-diameter wood, with light fuel oil as the reserve fuel.

In a heating co-operative, the action model is such that forest owners collaborate in the procurement of the fuel raw material and delivery of the fuel to the customer's premises. The co-operative's members are also in a position to earn revenues in the form of interest paid on the invested capital and dividends paid out by the co-operative. A heating co-operative must have

at least five members. The co-operative solution is appropriate when dealing with heating entities larger than single building, e.g. district heating plants. In these cases the plant size is between 0.5 MW and 5.0 MW. A smaller action model is that of a fuelwood co-operative responsible merely for procuring and delivering wood chips to the plant.

There are several other forms of heating entrepreneurship in which the heating entrepreneur's tasks vary according to the stage of work in the chain of events between procurement of the fuel raw material and heating. In cases where the entrepreneur is unable to procure enough fuelwood from his own woodlot, he can supplement his stock of fuelwood through purchasing standing wood and then harvesting it himself. In some cases it may be more economic to use the services of an another entrepreneur to provide the chipped wood rather than himself invest in the required equipment. Also, chip transportation can be contracted to another entrepreneur.

The action model varies depending on the harvesting equipment and chipping equipment, and also according to the ownership of the heating equipment. Chip-fired heating devices are usually owned by the purchaser of the heating energy, usually the local municipality. In the case of larger entities, the energy co-operative may also own the district heating plant and the energy distribution network belonging to it. Yet another model has the heating entrepreneur investing in chip-fired heating equipment, but the purchaser then redeems the equipment within an appointed time.

Finland has a significant fuelwood reserve in the small-diameter trees and felling residues that do not fulfil the quality requirements imposed on industrial wood. The farm woodlot often contains more fuelwood than can be consumed on the farm. This surplus wood can be used as raw material by heating entrepreneurs. Considering the under-utilisation of forests in Finland, harvesting this material does not pose a problem for the supply of the raw material to industry. The use of the small-diameter trees for energy generation promotes forestry and enhances opportunities for practising multi-purpose forestry.

The mechanisation-of timber harvesting means an increase in first-thinnings work by forest owners. The recovery of wood material of below pulpwood diameter for energy generation improves the profitability of this work. Society encourages the treatment of otherwise unprofitable stands in Finland by subsidising, for instance, rehabilitation felling and tending of young stands, and by paying a subsidy in cases where energy wood fulfilling certain requirements is collected in marked stands.

Farms have plenty of relatively new equipment and equipment which is partly under-utilised. This applies especially to machines and devices used in timber harvesting and making fuelwood. Generally speaking, Finnish farms are well-equipped in terms of their production technology especially for engaging in wood fuel harvesting as is the case with heating entrepreneurship. The equipment used in production of fuelwood for own consumption is usually also suitable as such in heating entrepreneurship and little other special equipment is needed. At the same time, the equipment used in production of fuelwood for own consumption can be further utilised, and this improves the profitability of the use of fuelwood for own consumption.

Modern heating devices are already so advanced that heating with a wood-based heating no longer ties up the user 24-hours-a-day as was the case earlier. Also, modern heating devices do not essentially differ from the ones used on farms. Thus, looking after such heating equipment is not an obstacle to becoming a heating entrepreneur if the entrepreneur has become accustomed to heating the farm on wood.

Buildings owned by municipalities and especially those owned by other public organisations and lying outside district heating networks represent a major potential for new heating entrepreneurs. Some of these sites are oil-fired schoolhouses, day-care centres, and old people's homes, and residential buildings owned by municipalities. Sites within district heating networks have yielded good experiences as regards the co-operative operation model. Another future category of clientele is that of private housing corporations.

From the point of view of municipalities, among the advantages connected to heating entrepreneurship based on chip heating are the following: increased use of local labour, supply of local raw materials, reliability of heating of buildings, and savings in costs. Furthermore, the fact that the money previously been spent on purchasing oil now circulated locally promoting local livelihoods and also increased the amount of locally taxable incomes is considered important at the municipal level.

Keywords : fuelwood, bioenergy , entrepreneurship

SOLAR SYSTEMS FOR DOMESTIC HOT WATER AND SPACE HEATING

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1. THE SOLAR THERMAL MARKET IN EUROPE

The European solar thermal industry has reached maturity, after 20 years technical development. High quality products are available, solar systems are reliable and their productivity can be guaranteed. Since 1989, the market has grown at an average annual rate of 18% and all the signs point to further growth.

In 1994, over half a million square meters of glazed solar collectors were manufactured and sold, principally for domestic hot water production in the European Union. Solar heating systems for swimming-pools form another dynamic market, for which 160.000 square meters of unglazed collectors were also produced and sold.

Over the last few years, the principle national markets have moved away from Southern Europe and present market development is mainly to be found in Austria, Germany, Denmark and Greece, which remains the Southern European exception. In 1994, these four countries, accounted for 85% of all solar collector sales in the European Union. There are also, dynamic small markets in the Netherlands and Sweden.

The recent market growth in the Northern countries of Europe stems from the environmental consciousness of the population. Furthermore, as the market grows, solar applications are becoming increasingly cost effective. In Southern Europe, environmental problems appear to be less of a vital issue and this is one of the reasons for the largely unexploited solar potential in Italy, France, Spain and Portugal.

2. SYSTEMS

2.1 Solar Systems for Domestic Hot Water

Domestic water is usually heated either with electricity or with solid fuels, gas or oil in a boiler. If this boiler is used in summer only for water heating, in particular older models operate extremely inefficiently. This implies not only a large fuel consumption in proportion to the heat used, but also usually major environmental pollution. During the period in which space heating is not needed, the domestic water can be heated in a environmentally friendly and economic way with a solar system.

The energy supplied by the sun is sufficient to cover between 80 and 95% of the hot water demand during the warmer half of the year, depending on the dimensioning of the system. If the hot water consumption is adapted slightly to respond to the solar radiation

profile, it is possible to completely dispense with other forms of energy for this purpose during these months.
During the transitional and winter months, the energy supply is still sufficient to preheat the domestic water i.e. the temperature of the inlet water must only be raised by a smaller amount by the heating boiler or electric element. In the colder half year, water temperatures between 30 and 50°C are still reached on sunny days. Thus, the energy-saving effect in winter is still considerable.

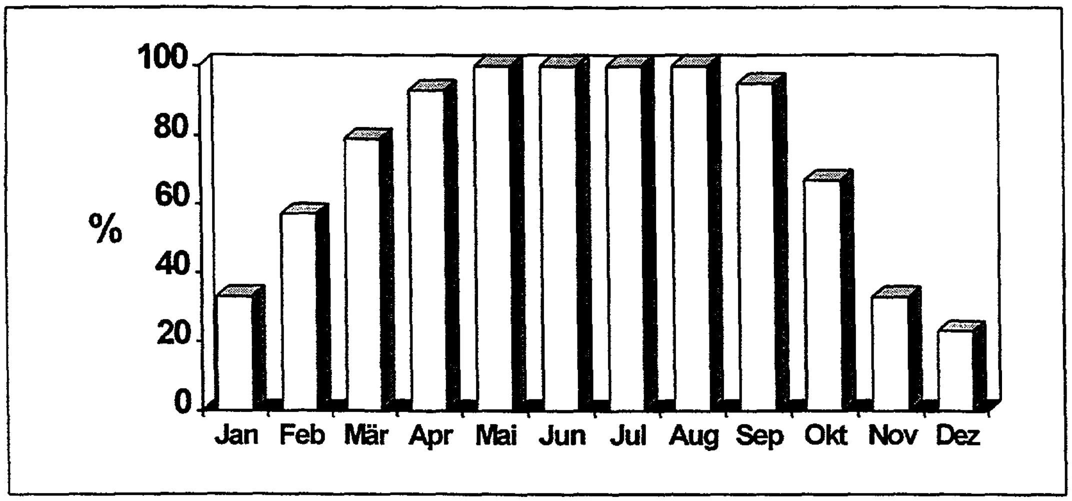

Fig. 2: Solar fraction of a solar DHW-System situated in Graz, Austria, hot water demand 200l/d, storage tank volume 500 liter, collector area: 9 m², $\eta_0 = 0,8$, $U_{eff} = 4,5$ W/m² K

2.1.1 GRAVITY-DRIVEN SYSTEMS WITH NATURAL CONVECTION

This systems take advantage of gravity in their operation and do not need a circulation pump. The water heated in the collector rises to the top and cooler water from the tank flows in after it (thermosyphon principle). The water in the tank continues to be heated as long as the temperature difference between the collector and the tank content is large enough to maintain the circulation. As the buoyant forces are relatively small, pipes with a large cross-section, as compared to those for pumped systems, must be used. In addition, the pipes should be kept as short and straight as possible to achieve the lowest flow resistance.
The simplest types of thermosyphon solar systems are widely used in Southern European countries. They are usually mouted on flat roofs and consist essentially of only a collector, a tank and the necessary piping.

2.1.2 DOUBLE-CIRCUIT SYSTEMS WITH FORCED CIRCULATION

Under Central and Northern European climatic conditions, double-circuit systems with forced circulation are almost exclusively used. The collector circuit is driven by a circulation pump. Characteristic to this system is the separation of the collector and the tank as the collectors are usually mounted on the roof and the tank is installed in the basement of the house.

Description of a Domestic Hot Water System (DHW-System)
The incoming solar radiation is converted by the collector (1) into heat. This heat is transported by a heat transfer medium (water/anti-freeze mixture) in pipes (2) to a storage tank/boiler (3). There, the heat is transferred through a heat exchanger (4) to the domestic water and thus becomes utilizable. The storage tank should be dimensioned in such a way that its volume corresponds to the hot water demand of at least two days.
The installation of an additional (e.g. electric) heater (5) ensures that sufficient amounts of hot water are available even during long and continuous periods of overcast weather.
The water which has been cooled in the heat exchanger flows then back to the collector.
The heat transfer medium is circulated by a circulation pump (6). An electronic control (7) ensures that the pump is only turned on when an energy gain from the solar collector is expected, i.e. when the medium in the collector is warmer than the domestic hot water in the tank.
Both the storage tank and the pipes are well insulated to avoid unnecessary losses.
Additionally, thermometers (8) in the inlet- and outlet pipes belong to the basic equipment of the system. They are preferably installed close to the storage tank.
Temperature dependent volume changes in the fluid are compensated by the expansion tank (9), keeping the operating pressure in the system constant.

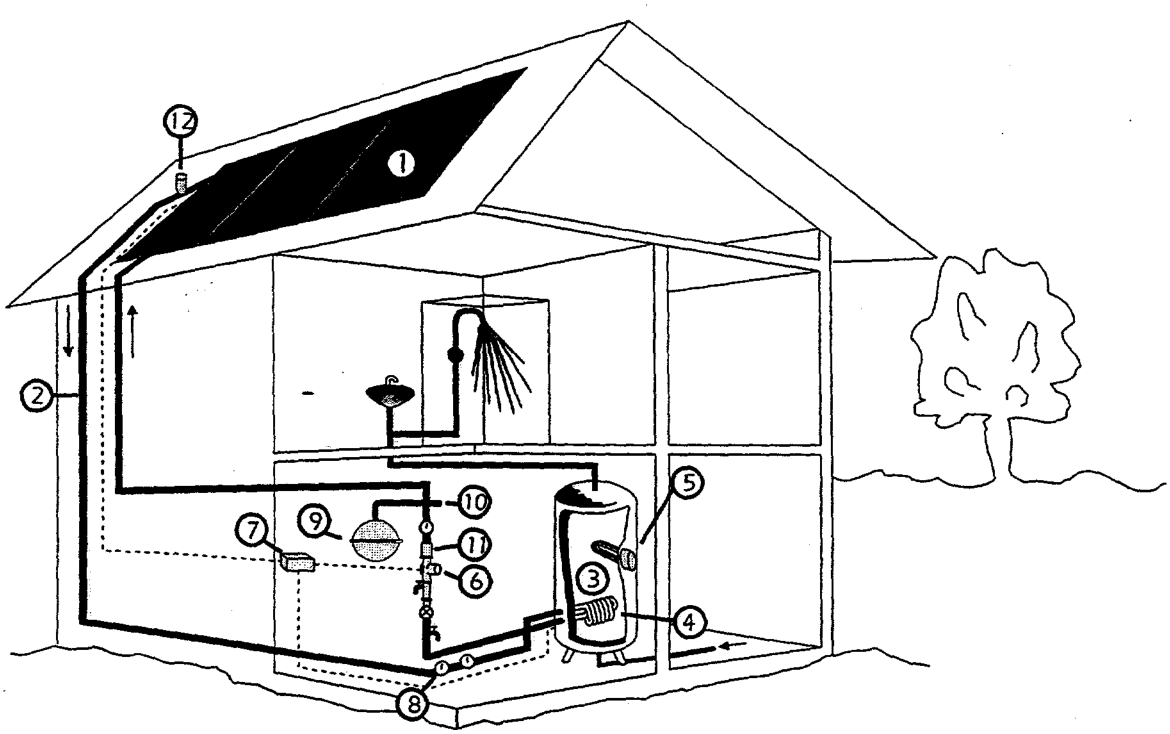

Fig. 4:. Illustration of a solar hot water system with forced circulation.

The gravity brake (11) prevents the heat from flowing back to the top if a standstill in the system occurs. A pressure relief valve (10) allows fluid to escape if the system pressure becomes too high. An air escape valve (12) is installed at the highest point allowing air in the piping to escape. Inlet and outlet taps complete the system.
In general during the colder half of the year, the subsequent heating of the domestic water is performed with a second heat exchanger by the heating boiler instead of, or in addition to the electrical auxiliary heating.

2.1.2.1 Components and Dimensioning of DHW-Systems

Hot Water Demand

The hot water demand in a household is decisive for the dimensioning of a domestic hot water (DHW) solar system. However, this depends on the users' habits. For example, if a family is used to have a shower rather than a bath, the daily hot water demand is significantly lower than if a bath is frequently taken. The daily hot water demand can be estimated as shown in Table 3 and 4.

	hot water demand [litres/day]	temperature [°C]
dishwashing per person and day	12-15	50
hand-washing	2-5	40
shampooing	10-15	40
having a shower	30-60	40
having a bath (normal size)	120-180	40
having a bath (large size)	250-400	40

Table1. Approximate values for the estimation of the daily hot water demand.

		low demand (litres)	medium demand (litres)	high demand (litres)
residential buildings	per person and day	30	50	60
sport facilities	per shower	30	45	60
restaurants	per seat	10	25	45
accommodation	per bed	30	50	100

Table 2. Hot water demand for different users at a hot water temperature of 45 °C.

The Storage Tank Capacity

When the daily hot water demand has been determined, the volume of the storage tank can be specified. It should be some 2 to 2.5 fold the daily demand so that consumption peaks can be met well and cloudy days can be compensated.

An example: For an average hot water demand (HWD) of 50 litres per person (P), the daily demand (DD) for a four-person household is 200 litres. The volume of the storage tank (V_{St}) is thus calculated as follows:

$$V_{St} = \mathbf{HWD \times P \times 2.5 = 50 \times 4 \times 2.5 = 500\ litres}$$

As the manufacturers do not offer tanks in every possible size, the choice has to be made among those generally available on the market. However, it is recommended that the storage tank capacity is not less than 90% and not more than 120% of the calculated volume.
The usually available storage sizes include storage volumes of 300, (400), and 500 litres. Therefore, in case of our example a storage volume of 500 litres will be chosen.

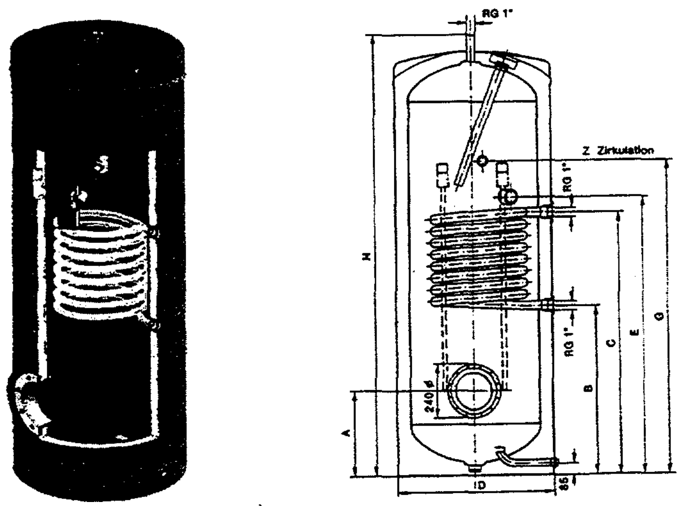

Fig. 5: Example for a solar storage tank (AUSTRIA EMAIL)

Heat Exchanger

Domestic hot water solar systems operating during the whole year need a heat exchanger, as the collector circuit (filled with a heat transfer medium) and the hot water circuit are separated.
The dimensioning of the heat exchanger influences directly the efficiency of the whole system and thus has to be considered carefully. Moreover, the heat exchanger should be chosen according to the storage tank used. Guidelines for the dimensioning of heat exchangers are shown in Table 3.
In small solar systems which are usually installed in single-family houses, internal heat exchangers (either smooth or ribbed pipe heat exchangers) are preferred. External heat exchangers (pipe bundle or plate heat exchangers) are only used for more complex systems with large storage tanks.

Types of Collectors

Plastic Absorber for the Heating of a Swimming Pool

Due to their limited pressure and temperature durability, plastic absorbers are mainly used for pool water heating. In this case, the desired temperature level is only a few degrees higher than the ambient temperature. Thus, simple plastic absorbers, which due to their low operating temperature can be usually mounted uncovered on a flat roof, are sufficient. As they consist entirely of plastic, they have the advantage of single-circuit operation. The chlorinated pool water is pumped directly through the absorbers by a circulation pump and no heat exchanger is needed.

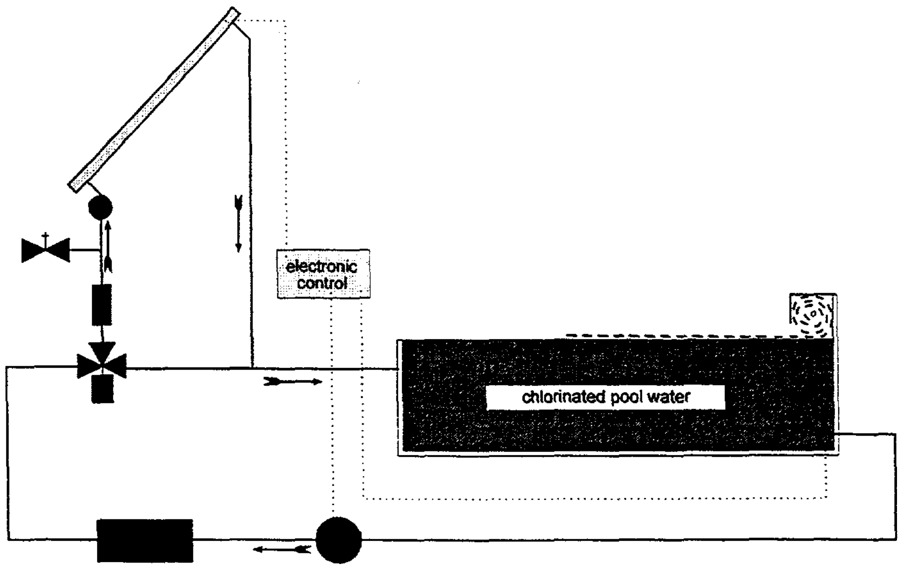

Fig. 6: Solar heating system for a swimming pool (single-circuit system)

If a filter pump is already existing it can be used for the solar circuit, too. In this case, an adequate dimensioning of the pump is most important. Plastic collectors are only operated during the summer months and have to be emptied before the first frost.

Flat-plate collectors, as describedon on the next pages, can be used for heating of a swimming pool in a sensible way, if besides the pool heating an additional consumer (e.g. domestic hot water, space heating during the winter months) can be supplied.

Concentrating Collectors

In concentrating collectors, the sunlight is concentrated by parabolic troughs or concave mirrors on a pipe or a certain point; by this means high temperatures are reached (burning glass effect).
These collectors are particularly used in solar plants for process heat supply (250 °C to 800 °C).
In contrast to flat-plate collectors which utilize global radiation (i.e. both direct and diffuse radiation), concentrating collectors have the disadvantage of only utilizing the direct radiation. In addition, these collectors have to be tracked exactly according the corresponding position of the sun to ensure focussing of the solar radiation. These high expenses are not typical for flat-plate collectors which can be mounted directly on the roof or on a suitable frame on the ground near the house.

Evacuated Collectors

Because of technical reasons, most of the evacuated collectors are constructed as tube collectors. In this case, a thin absorber strip with selective coating is closed inside a highly light transparent and heat resistant glass tube. Through evacuation of the space between glass cover and absorber, the losses are reduced highly as no convection and no heat losses by air conduction can occur.

Evacuated tube collectors obtain higher yearly solar yields per square unit in domestic hot water systems than flat-plate collectors do, but due to their higher price, the market penetration is still low. In Austria, the share of the market is at present about 1%.

Flat-plate Collectors

For domestic hot water and also increasingly for solar space heating, flat-plate collectors are mainly used. As all following dimensioning and design guidelines refer to this type of collector, it will be discussed more in detail.
The flat-plate collector consists essentially of the collector box, the absorber, heat insulation and transparent cover.

The incident solar radiation penetrates the transparent cover (glass) and strikes the absorber. The absorber converts the radiant energy by means of absorption to heat. As a result, the temperature of the absorber increases.

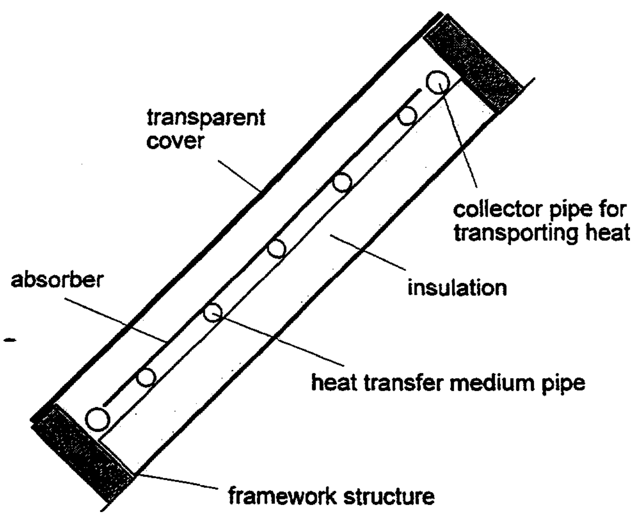

Fig. 7: Sectional view of a flat-plate collector.

This greenhouse effect can be observed also in daily life. For example, in a car which is exposed for a short time to the sun, the inside temperature raises quickly and reaches high values especially when the interior furnishing is dark. In this case too, solar radiation penetrates a window and is converted to heat when striking the dark surface of the interior furnishing. The absorber consists of a black coated metal plate and utilizes this effect particularly well.

Losses of a Flat-plate Collector

In the first instance, the solar radiation hits the transparent cover of the collector. Because of reflections both on the surface and at the interface (transmission) of the cover, a part of the radiation is lost for further utilization in the collector. The reflection losses depend on the angle of incidence, the number of covers, and their refraction index, whereas the transmission losses are determined by the light transparency of the material. As plastic covers degrade relatively fast and thus show increasing transmission losses, glass covers have in particular proved to be successful.

Depending on the type of coating, the solar radiation which is striking the absorber is converted almost entirely into heat. The coating should have both a high absorptance and the lowest possible emittance. The capability of absorption is characterized by the absorption coefficient α and mainly determined by the black colour of the absorber. The absorption coefficient for a solar coating with solar varnish as well as for good selective coatings is between 0.94 and 0.97.
A part of the heat being produced at the surface of the absorber is emitted again in form of infrared radiation. The infrared radiation and solar radiation differ in wavelength. The emitted infrared radiation has a high wave length and is for the most part reflected again at the cover (green house effect).
The emission coefficient ε is decisive for the heat losses through long wave radiation. By means of a special mixture of coating as well as the surface structure, heat radiation can be reduced. For coatings with solar varnish, the emission coefficient lies between 0.86 and 0.88, for selective coatings it is only 0.10 to 0.20.
The application of the coating can be done either by spraying (in case of coating with solar varnish), or by galvanic means or through a glueable thin foil (in case of selective coatings).

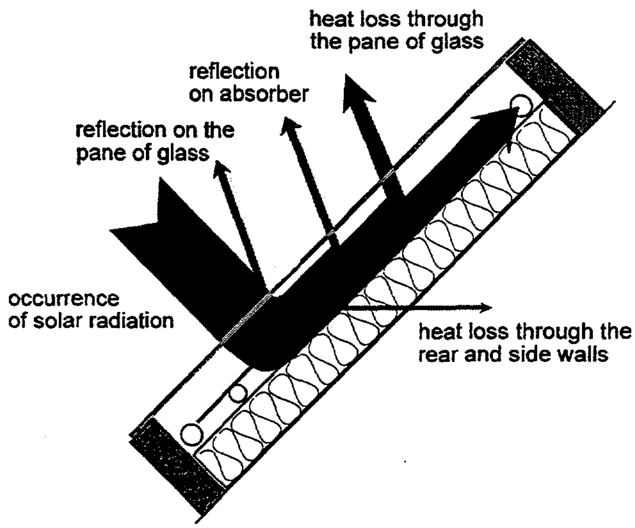

Fig. 8: Losses of a flat-plate collector

At present TeknoTerm, a swedish and TINOX a german company offer good selective coatings which are applied by the special physical process of sputtering. Compared to galvanic methods, this technique results in a much more ecologically benign and less energy requiring coating.

Heat losses are also caused by convection and can be reduced by the transparent cover. The convection losses depend significantly on the distance between absorber and cover. If a second cover, for example a foil, is used, these losses can be furthermore reduced. Naturally, these measures raise the costs and should therefore be included in the cost-benefit analyses.
In addition, heat losses also occur at the back side of the absorber. If an adequate UV and heat-resistant insulation is attached, these are relatively low.
Depending on the dimensioning, annual yields of 250 kWh/m^2 to 350 kWh/m^2 can be achieved with flat-plate collectors in domestic hot water systems with an average hot water demand.

Characteristic Values of Flat-plate Collectors

Collector Efficiency Curve
The collector efficiency curve is an important physical property of a solar collector. The efficiency of a collector is defined as the ratio of the energy amount transferred from the collector to the heat transfer medium to the incident radiant energy on the collector. Especially for temperatures (heat transfer fluid) higher than 40 °C, high efficiency values are desirable. The efficiency depends on the quality of the absorber surface, the geometry of the absorber, the heat conductivity of the absorber, the transparency of the cover, and the heat losses of the collector through infrared radiation, conduction, and convection. A quantitative comparison indicates that the efficiency is particularly dominated by the radiation losses.

The efficiency for a certain collector is not a fixed value, but is dependent on the application, e.g. temperature levels, wind speed, etc. Thus, a characteristic curve is obtained by plotting the efficiency from above as a function of the ratio of the temperature difference of the average heat transfer temperature of the collector and the ambient temperature (T_{Km}-T_A) to the incident radiant energy G_T.
The highest possible efficiency, i.e. the efficiency at which the average temperature of the collector T_{Km} and the ambient temperature T_A are equal (no heat losses to the environment) is called the conversion factor η_0.

Conversion Factor η_0
The conversion factor is defined as the maximum efficiency of a collector under the precondition that the average temperature of the heat transfer medium in the absorber equals the ambient temperature.

Heat Loss Coefficient U_L (W/m^2 K)
The heat loss coefficient is the average heat loss of a collector per m^2 effective collector area divided by the temperature difference between absorber and ambient temperature.

Stagnation Temperature (°C)
The stagnation temperature is the highest obtainable absorber temperature (no output withdrawn) when the solar radiation intensity is 1,000 W/m^2 on the outermost transparent cover at an ambient temperature of 32 °C.

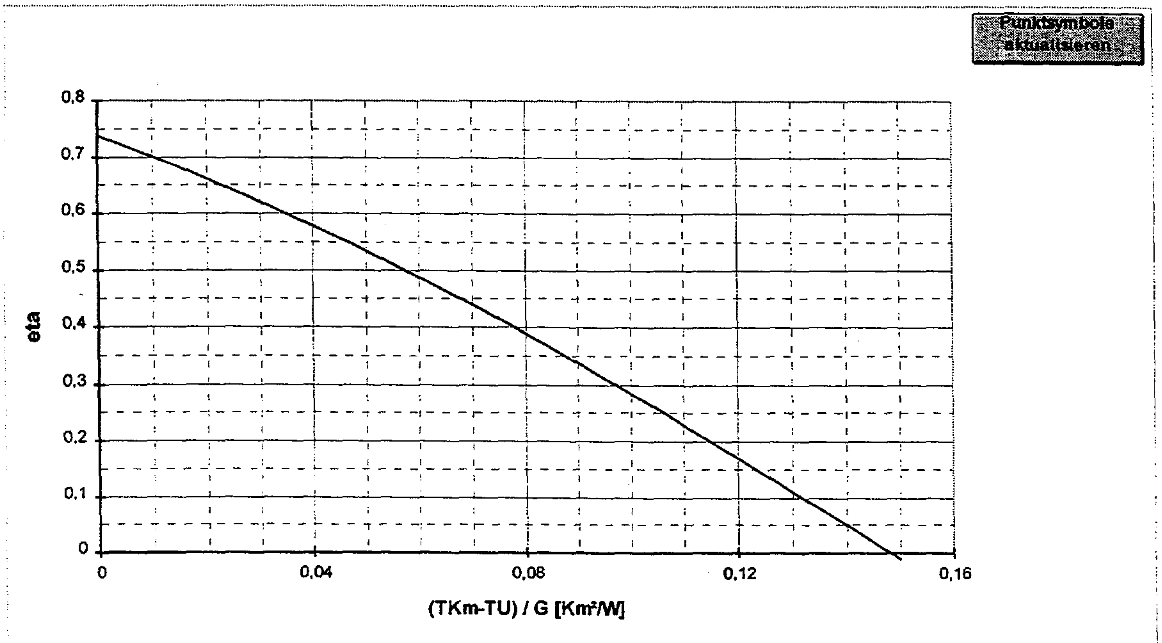

Figure 9. Collector efficiency curve of a flat-plate collector

Location, Tilt, and Orientation of the Collectors

The most usual place to install collectors is the roof area. If it is not possible to mount the collectors on the roof, they can also be mounted on a suitable frame near the house, they can be integrated into an earth bank, or mounted on a flat roof. However, in each case attention should be paid to keeping the pipes to and from the tank as short as possible.
South-orientated surfaces are best suited for the installation of solar collectors. A deviation of 45° to the east or west is nevertheless possible, as it does not reduce the yield significantly. Furthermore, a deviation from the ideal southern orientation and roof pitch can be compensated to a certain degree by a larger collector area.

In addition, care should be taken that the collectors are not shaded at any time of the year, either by trees or buildings, if possible.
Apart from the effect of the characteristics of the collector itself, the output of the solar system is strongly dependent on the inclination angle of the collector to the sun. The largest yield is obtained when the collector is always orientated perpendicular to the sun. However, the optimal tilt angle for the collectors varies according to the season, as the sun is higher in the sky in summer than in winter. For a south-orientated surface, the energy gain in summer is largest for a tilt angle of 20 to 30°. In winter, the most

favourable angle would be about 60°. An angle of 45° is ideal for use throughout the year.

This angle is advantageous because the collectors are optimally orientated towards the sun during the transitional seasons. This hardly brings any disadvantage for the summer as there is usually an "oversupply" of solar radiation, so that a slight reduction in the yield can be neglected.

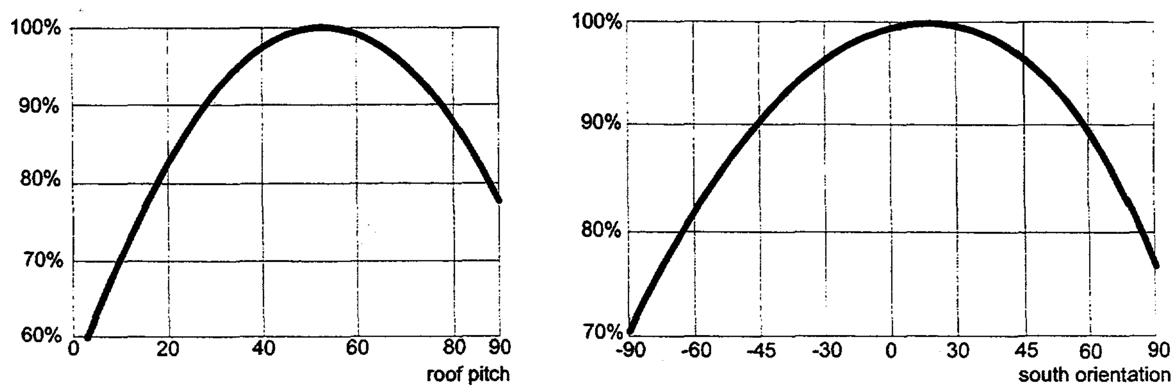

Fig. 19: Solar gain as a function of roof pitch and south-orientation.

Dimensioning Guidelines

The basis for the dimensioning of solar systems is the highest possible solar gains, i.e. solar fractions of about 70%, and avoidance of a solar overproduction in summer. This kind of dimensioning results in a solar fraction of almost 100% during the months outside the heating season so that during this time no additional heating for hot water is needed.

The dimensioning indicated in Table 3 is to be understood as guidelines. In order to gain exact information, a calculation based on the system site characteristics in question is recommended. Such calculations can be performed with the help of simulation programs. These give exact predictions of the solar fraction and the system efficiency for the planned system as well as information on the additional energy needed during the winter months.

daily hot water demand [litres]	solar tank capacity [litres]	collector area* SV [m²]	collector area* SS [m²]	heat exchanger [m²]
100-200	300	6-8	5-6	1.8
200-300	500	8-11	6-8	2.5
300-500	800	12-15	9-12	3.6

Table 3. Dimensioning of domestic hot water solar systems.

*depending on the deviation from the south-orientation, the ideal roof pitch, and climatic conditions

SV ... coating of solar varnish

SS ... selective coating (selective strip systems)

Piping for the Collector Circuit

In solar domestic hot water systems mainly copper pipes are used. They are well suitable and have been successfully applied to thousands of systems. The use of plastic piping is not recommended because it is, among other reasons, pervious to oxygen. Galvanized steel pipes are also unsuitable as the heat transfer medium (water/anti-freeze mixture) causes corrosion problems.

Cross-Sections of Pipes

The choice of the pipes cross-section depends essentially on the collector area, the piping length, and the concentration of the anti-freeze fluid in the heat transfer medium. The performance of the collectors decreases significantly when the flow rate remains under 40 l/h per m^2 of collector area. Therefore, a flow rate of 40 to 60 l/h per m^2 of collector area is recommended. The values shown in Table 4 are guidelines for the use of copper pipes.

collector area [m²]	piping length up to 20m pipe diameter [mm]	piping length 20-50m pipe diameter [mm]
5-8	18	18
8-11	18	22
11-15	22	22

Table 4. Pipe diameters for the solar circuit (inlet- and outlet pipes).

The Hydraulic Connection of the Collectors

In order to achieve the best possible yield from a collector area, the correct hydraulic connection of the single collectors or the single absorbers, respectively, is most important. A basic principle therefore is to ensure that the flow through the absorber is homogenous and adequate. To guarantee that the temperature raise stays in an acceptable range even at high radiation intensity, a flow rate of 40 to 60 litres/m^2 collector area and hour has to be achieved. At maximum solar insolation the temperature difference between inlet- and outlet pipes should not exceed 10 to 12 °C. If the collectors are connected in series an adequate flow rate is only achievable with high pump performance as the flow resistance increases exponentially. Thus, parallel connection is usually preferred in solar domestic hot water systems. Series-parallel connection of the collectors is mostly used only for large collector areas.
Parallel connection means that each single absorber or absorber strip is connected to both an inlet- and outlet manifold. In order to ensure that the flow through all the parallel strings is as even as possible, the connection is made according to the „Tichelmann“ principle. Therefore, inlet and outlet pipes are connected to the absorber on the respectively opposite ends. In this manner, the same piping length results for each absorber and absorber strip, and correspondingly the flow resistance is equal. The

piping loop which usually results from the Tichelmann connection should preferably be part of the somewhat cooler outlet pipe.

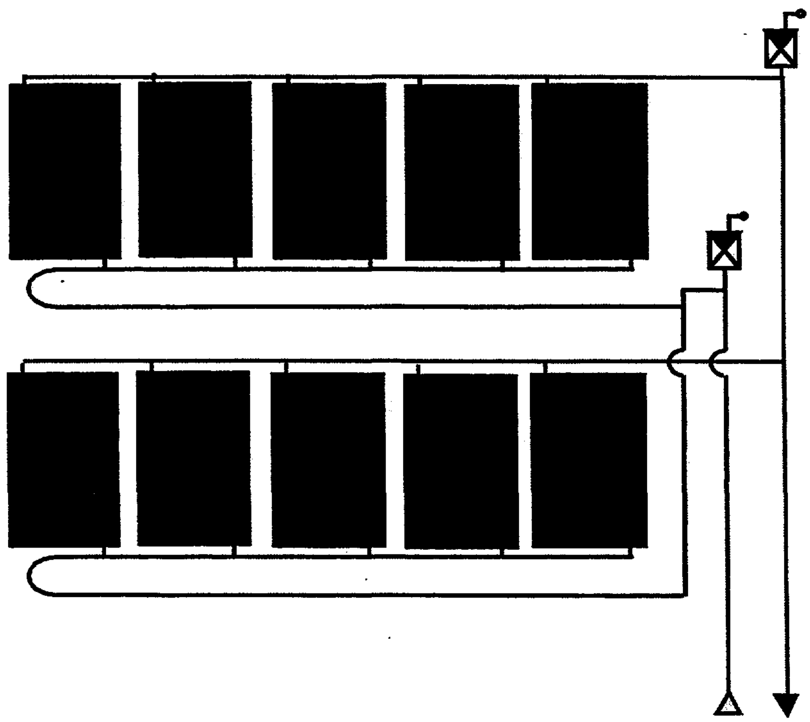

Fig. 11: Series/parallel connection of Collectors

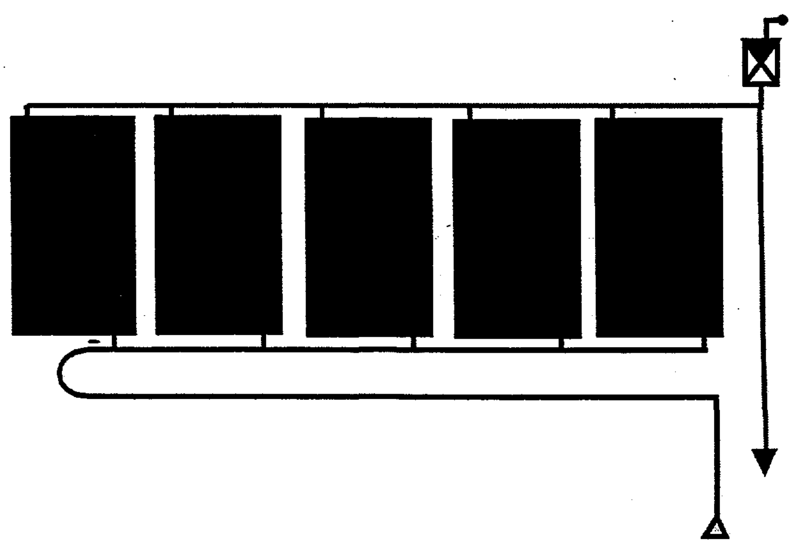

Fig. 12: Parallel connection of flat-plate collectors

Strip absorbers are connected in a similar way. Here, the construction of big collector fields in particular for the case of roof integration with wooden frames is possible without any bigger efforts for the connection, as the parallel absorber strips can be converted up to a length of 6 m. Thus, in this case there are not any more single collector boxes, but a collector frame contains only one big absorber which is covered by several glasses.

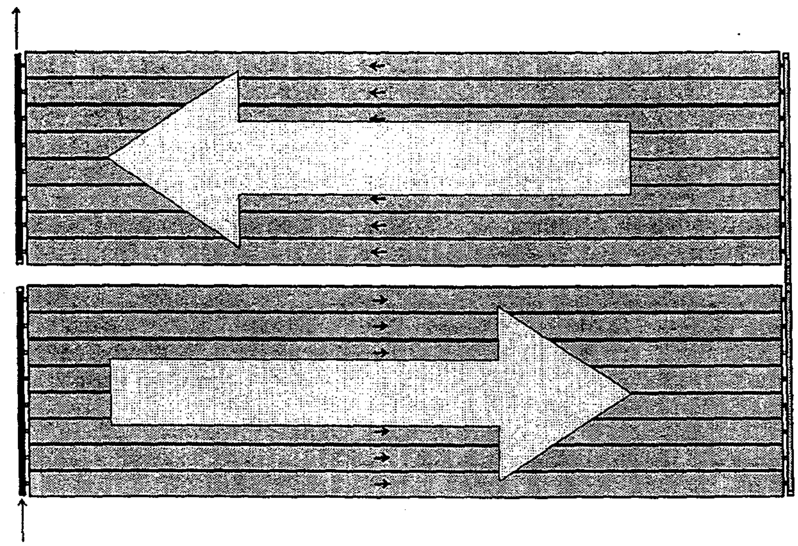

Fig. 13: Parallel connection of strip absorbers.

Additional Energy

As the solar system cannot completely supply the hot water demand during periods with little solar input (winter season), a possibility for auxiliary heating has to be provided. In principle, this can be a gas-fuelled, continuous-flow heater subsequent to the tank, an electric heating element, or a conventional heating boiler.

From energy considerations the best solution is a subsequent, gas-fuelled, continuous-flow heater which heats just the amount of water required at the corresponding temperature level. The distribution and storage losses are thereby considerably reduced.

For both ecological and economic reasons, supplementary heating with an electric heating element should only be done out of the heating season or if a heating boiler is not available for winter operation.

In the usual storage tanks, a 6/4" socket for the installation of an electric heating element is provided. In any case, the socket should be in the upper third of the tank to avoid unnecessary stand-by losses and to keep a sufficiently large pre-heating volume available for the solar system. The maximum heating temperature can usually be set as desired but should not exceed 60 °C.

The most frequently occurring form of auxiliary heating uses the heating boiler and an additional heat exchanger in the tank. The heat exchanger should be mounted in the upper half of the storage tank so that it is possible to heat only the daily consumption, i.e. about half of the storage tank volume.

If the auxiliary heat exchanger is mounted too close above the solar heat exchanger, the solar system is not able to deliver heat to the storage tank during the heating period. This also results in lower solar fractions. If the heat exchanger is mounted correctly the solar system is able to heat up the storage water from a temperature of 10 °C to a temperature of 30 to 50 °C on sunny winter days. Figure 29. Auxiliary heating of hot water by a central boiler in winter.

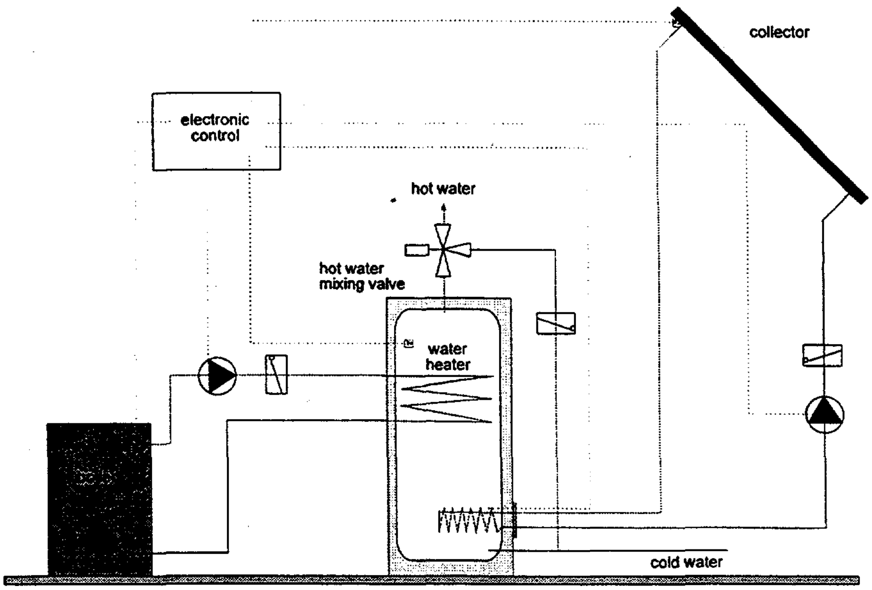

Fig.14: Auxiliary heating of hot water by a boiler in winter

2.2 SOLAR SYSTEMS FOR SPACE HEATING

The past few years have shown that thermal solar systems are already technically mature and reliable. Some thousands of installed systems prove daily the practicability of this undoubtedly environmentally most compatible form of energy utilization.
Motivated and confirmed in their convictions by the solar domestic hot water systems, an increasing number of building owners is considering the use of solar energy for space heating.
As the energy supply is inversely proportional to the energy demand - i.e. during summer when only little energy for heating purposes is required the energy supply is high, and during winter when much energy is needed the supply is low - the key question is how to store the energy from the summer to the winter.

Various systems completed in recent years demonstrate that it is possible to store the heat from summer for the winter in large water tanks (seasonal storage with 100 m^3 for 100 m^2 living area), and thus to use only solar energy for heating. One of the most known examples is the "Jenni Solar House" in Switzerland. In any case, prerequisite for both solar and partially solar space heating is high thermal insulating standards. The annual heating energy consumption should be less than 70 kWh per m^2 living area. Low-temperature heating systems, preferably floor- or wall surface heating, are further preconditions.

From an economical point of view, seasonal storage for single family houses and two-family houses is quite expensive and thus not generally applicable.
The second, economically more interesting concept for residential buildings is that of partially solar space heating. If collector areas of 20-50 m^2 are combined with buffer storage tanks (1-5 m^3) which are able to store heat for some hours (overnight) or for some days, solar fractions of up to about 50% can be achieved at reasonable costs compared to systems with seasonal storage.
The system prices can be reduced significantly if the absorbers are prepared and the collectors mounted by do-it-yourself groups under supervision of an expert.
For this kind of systems, mainly selective painted strip absorbers are used, as collector areas of 20-50 m^2 and in particular high winter yields are required. These strip systems allow furthermore a simple hydraulic connection of the collectors because they can be designed as large-area collectors.
Systems for solar space heating require the best possible south-orientation of the collectors and a tilt angle of at least 40°.

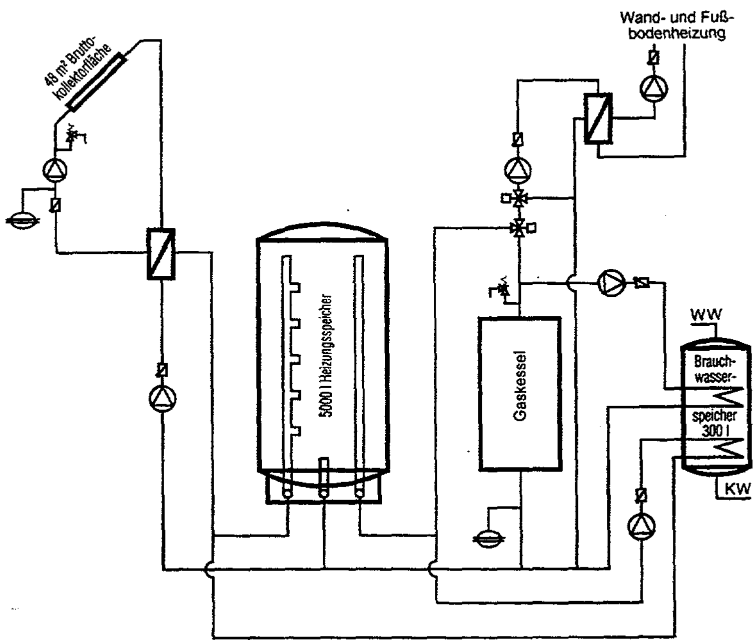

Figure 15. System-diagram of a partially solar space heating system.

REFERENCES

/1/ European Solar Industry Federation: Sun in Action - The Solar Thermal Market, A Strategic Plan for Action in Europe, Final Report, Commission of the European Communities - D.G. XVII, Altener Programme, 1996

BIOMASS FOR ENERGY

SMALL SCALE TECHNOLOGIES

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CONTENT:

1. BIOENERGY MARKET AND POTENTIAL

In the EU-region, except Austria and Sweden, the total amount of solid residues from agricultural land and forests has been estimated to about 102 millions tonnes per year. Assuming that the average energy content of the biomass is 14,5 GJ/t, this means an energy potential of appr. 1,5 EJ per year. Industrial and municipal waste add another 188 million tonnes annually, with an average energy content of 12 GJ/t representing a potential of 2,3 EJ/year.

Besides solid waste and residues, there is a large amount of liquid waste from agriculture and industry as well as from municipal waste. This adds up to about 529 million tonnes annually, which can be used for digestion to produce biogas. Landfill gas could contribute another 63 TWh of electricity per year.

If this EU bioenergy potential were to be used in power or combined heat and power stations, it would yield a total annual electricity production of appr. 450 TWh.

In addition to the use of waste for energy production, energy farming is also being discussed in Europe. In the same countries as above, at least 15-20 million ha of good agricultural land is expected to be taken out of food production by the year 2000. This could increase to more than 50 million ha during the next century. If all this land was used for energy farming, it would provide 3,6 to 4,8 EJ of bioenergy per year. This corresponds to appr. 350 to 670 TWh if the same biomass were combusted or gasified to generate electricity.

The present level of bioenergy utilisation varies very much among the European countries. In 1995 the average contribution of bioenergy to the total energy demand among EU-countries increased significantly. This was the result of the three new countries (Austria, Finland and Sweden) were bioenergy plays a significant role of the energy supply system.

In **Austria** renewables accounts for 27% of the total energy consumption of 1.143 PJ, of which biomass provides almost half. Almost 98% is fuelwood, bark (wood chips and other forest industry by-products). The fuelwood is used in more than 530.000 small woodburning installations and 400.000 tiled stoves, as well as 63.000 larger furnaces and 200 district heating plants. The other 2% is accounted for by biogas plants together with a small (0,4%) use of rapeseed methylester (RME) produced in six installation as a substitute for diesel fuel. Austria has been one of the pioneers in the production and promotion of biodiesel based on RME.

As shown in this example from Austria, much of the bioenergy is generated from thousands of small decentralised heating systems. Bioenergy is well suited for energy supply in rural areas and small villages.

2. DIFFERENT TYPES OF BIOFUEL

Biofuel can be divided into three categories:

- **Solid biofuel**
  Firewood, forest wastes, waste from sawmills, charcoal, agricultural residues (straw, grain), dung, peat, household and industrial waste.

- **Liquid biofuel**
  Alcoholes, vegetable oils, esterized vegetable oils.

- **Biogas**
  Gas from anaerobic digestion of livestock and poultry manure, producer gas, burn gases from pyrolysis process, landfill gas.

Solid biofuels can be used as raw materials or treated (compressed) to briquettes or pellets. The liquid and gas biofuels are converted from raw materials through different chemical processes, i.g. gasification, pyrolysis, esterization.

3. TECHNOLOGY

Energy is released from biomass by breaking down its chemical structure. This is achieved either by thermal conversion using heat, or by biological conversion using digestion and similar processes.

Combustion

Direct combustion take place in a boiler or a stove. The released energy may be used to heat up the surrounding air (stoves) or to produce hot water or steam (boilers) for heating purposes, industrial processes or steam for running turbines for electricity generation.

Gasification

Earlier days, gasification played an important part of the general energy supply system in towns. Coal gasification plants produced gas and the residue product was coke. The gas was distributed through gas pipes and used for heating, lighting and cooking. The coke was also used for heating in small stoves.

Today we can see a growing interest for gasification, now using residue products from agriculture and forestry industry.

The gasification process involves the partial combustion of a carbonaceous fuel to generate a combustible fuel gas rich in CO and H_2. A gasifier is basically an incinerator operating with an air deficit. Heat to sustain the process is derived from exothermic reactions, while the combustible components of the low-energy gas are primarily generated by endothermic reactions.

Gasification at atmospheric pressure yields a low energy gaseous fuel, typically containing 20% CO, 10% CO_2, 2% CH_4, 15% H_2, with the balance being N_2 and a carbon-rich char. Depending of the size of the plant, the gasification achieves a conversion efficiency of 25-40%.

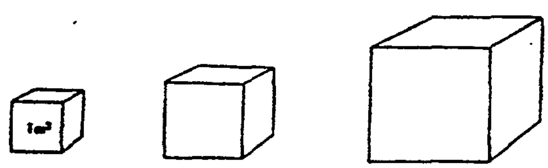
Pyrolysis
In pyrolysis, the fuel is heated in an oxygen-free atmosphere and the biomass is converted to gas, oil and char. Flash pyrolysis maximises the yield of liquid product and can transform up to 85% of the energy of the biomass into this form. The high heating rates used in flash pyrolysis mean that the biomass must be dry and cut into small particles. For this reason, the process is more suitable for straw and herbaceous crops than wood.

The liquid fuel from the pyrolysis are used for power generation and heating purposes.

Biological conversion
Common processes for biological conversion is:
- digestion of animal manure output, abattoir wastes etc. in biogas reactors (better control over the process)
- anaerobic digestion of household and industrial wastes in landfills (slow conversion, high losses)
- anaerobic digestion in natural cavities

Storing
The main part of the agricultural and forest residues are produced at a time of the year when the demand for heating is at a low or medium level. To minimise the fuel volumes, biomass can be treated into solid fuel as briquettes or into liquid fuel as alcoholes, vegetable oils and esterized vegetable oils.

Storing volumes equivalent to 1 m^3 oil



Oil no.2	Briquiettes (12% M.C)	Wood chips (40% MC)
1 m^3	3,5 m^3	12 m^3
840 kg	2200 kg	3800 kg

4. RELEVANT APPLICATIONS

The aim of this Thermie-project is to focus on practical renewable energy technologies for rural applications. The technology should have been demonstrated in the EU-region and be commercial available. The applications listed below are considered to meet the criterias for being relevant for the rural areas in the target regions.

All the given prices are based on typical prices in the Norwegian market. This might be somewhat different in the target regions, and the prices should be taken as estimates.

Most of the applications are dealing with combustion technologies and includes

- Log stoves burning firewood or briquettes.
- Pellets stoves.
- Boilers for central heating burning firewood, briquettes or multi fuel boilers.
- Conversion from coal or oil fires boilers to bioenergy
- Direct combustion of biogas for single users or a few-user grid
- Combined heat and power - cogeneration

4.1 Log stoves

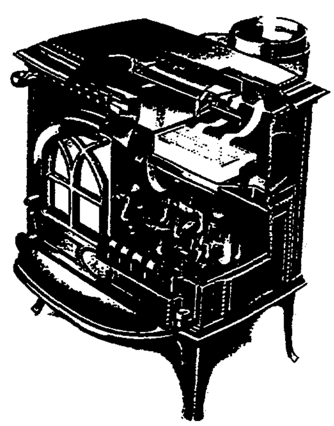
Log stoves burning firewood or briquettes is the traditional way for cooking and heating. For old stoves the typical thermal efficiency by optimal combustion conditions is about 60%. However, the efficiency is substantialy reduced at low loads.

Log stoves should be run with optimal air supply to prevent local air pollution.

For modern stoves the thermal efficiency is typical 80%, and the stoves are either equipped with double combustion chambers or a catalysator for clean combustion - even at low loads.

Capacity range	5-15 kW
Prices	600 - 2200 US$

Classic design
(Jøtul AS)



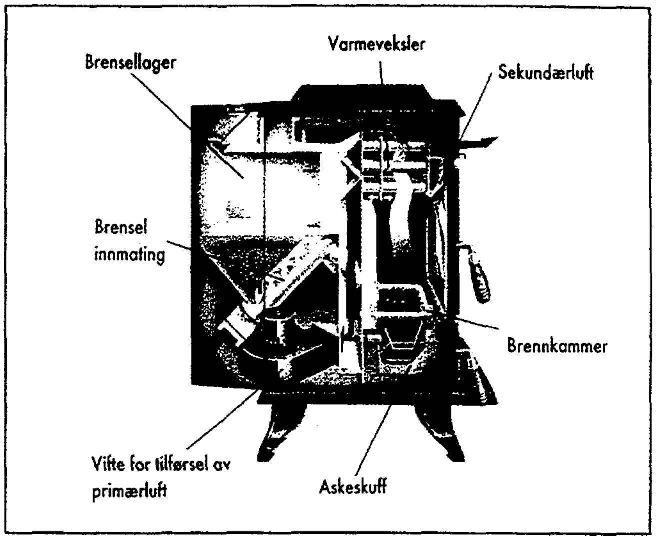
Catalyst stove
(Jøtul AS)

4.2 Pellets stoves

Pellets stoves have an automatic feeding systems for fuel and they can easily be regulated to different capacity ranges.

The maximum capacity of the available stoves are 12-15 kW and the typical thermal efficiency is 80%.

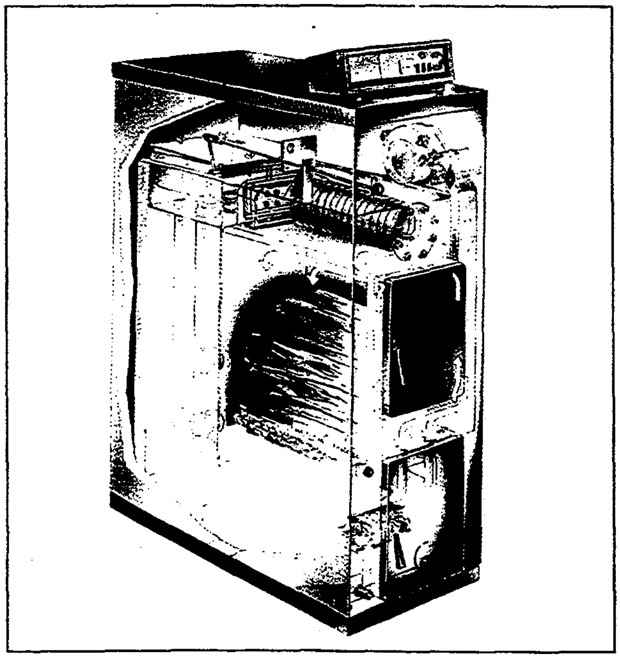
Prices: 2000-2600 US$ per unit.



4.3 Boilers

Central heating systems can be heated by boilers using firewood, briquettes, pellets, chips or straw as fuel. Other options are multifuel boilers using i.e. different agriculture or forest wastes and external burners/reactors for conversion of existing coal- or oil fired boilers.

Small scale boilers for firewood



Typical capacity range	15-75 kW
Typical thermal efficiency	85%
Prices	150 - 220 US$/kW

The prices include only the combustion equipment.

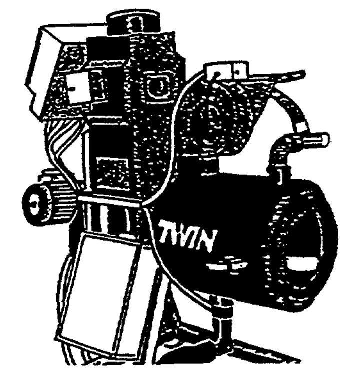
The feeding of fuel is manually operated, which makes it necessary to include a watertank for heat storage as a heat buffer.

Small scale boilers for pellets, chips or straw

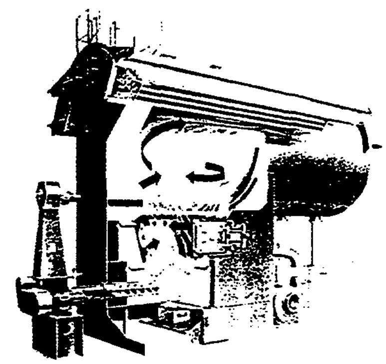
Typical capacity range	15-75 kW
Typical thermal efficiency	85%
Prices	150 - 220 US$/kW

The prices include just the combustion equipment.

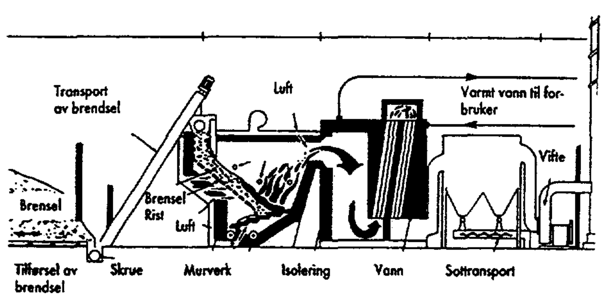
Large scale boilers for district heating or industrial purposes
- for briquettes, pellets, wood chips, straw, bark, household/industrial wastes etc.
Main technologies for modern boilers of medium and large size are listed below:



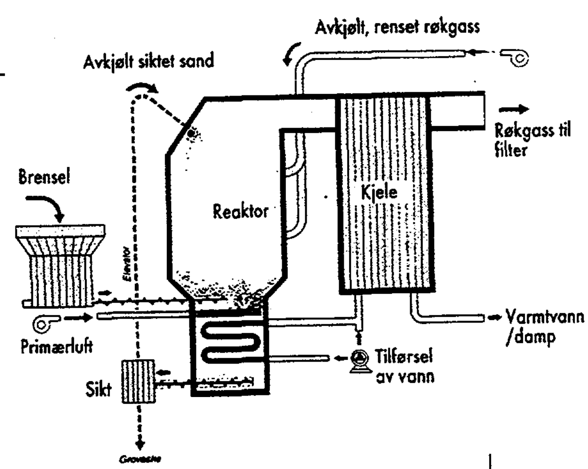
Burner/reactor,
capacity range: 10-1200 kW



Underfed stoker,
capacity range up to 500 kW



Grates - horizontal or tilted
moving or not moving,
capacity range from 500 kW



Fluidized bed -,
bubbling or circulating
capacity starts from 1 to 2 MW

The large scale boiler technologies above are ranked according to the ash content, complexity of the fuel and plants flexibility to the different types of fuel. Fluidized bed is the most flexible combustion system.

For burners and underfed stokers, the typical thermal efficiency are 80-85 %. If the installation includes equalisers and fuel dryers, the thermal efficiency might increase to appr. 90%.

Existing coal- or oil fired boilers can be converted to pellets, wood chips etc. by the installation of a special burner/reactor.

Prices for conversion from coal- and oilfired burners:	100 - 180 US$/kW
Prices for new plants	170 - 270 US$/kW.

Fluidized bed plants may achieve a thermal efficiency of 90-95%. Fluidized bed boilers are very flexible regarding type and grade of solid fuel.

Prices for plants > 10MW including combustion equipment only 70 - 180 US$/kW.

4.4 Biogas plants

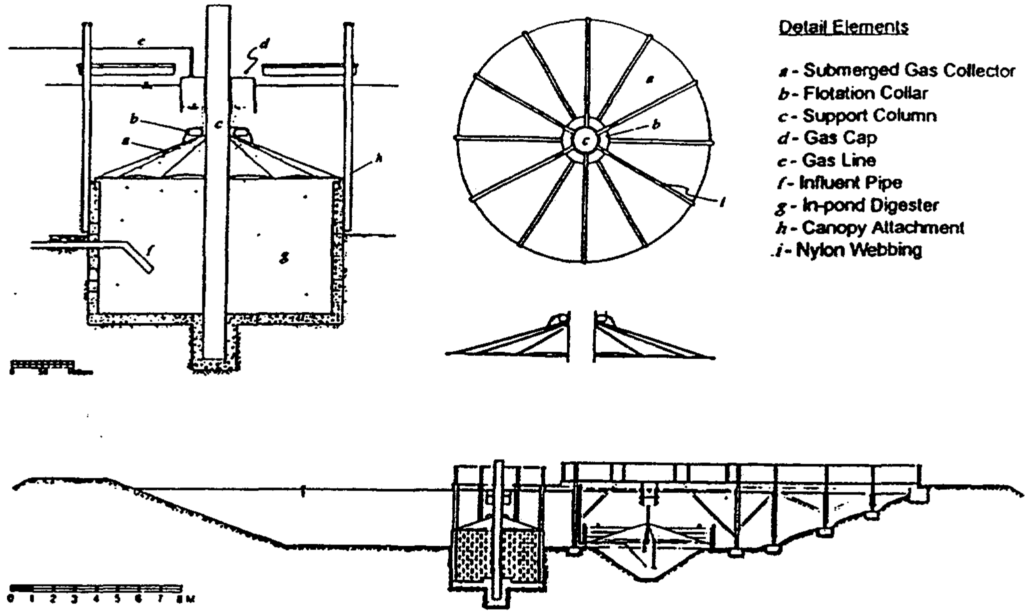
In rural areas in many countries "one family" biogas units are quite common. The plants are normally located at a cattle farm, where the dung and urine are drained into a tank/digester for gasification. The pressure in the tank builds up, through a pressure reduction valve the gas is piped to a container and from there to the kitchen cooker.

The plant is adequately equipped with a inspection chamber, overflow tank and outlet for the wet manure, thus the process goes automatically and smoothly through the plant system. The manure from the outlet is free of smell, indicating that the process is complete. The manure is a better fertiliser than raw cowdung.

Prices:

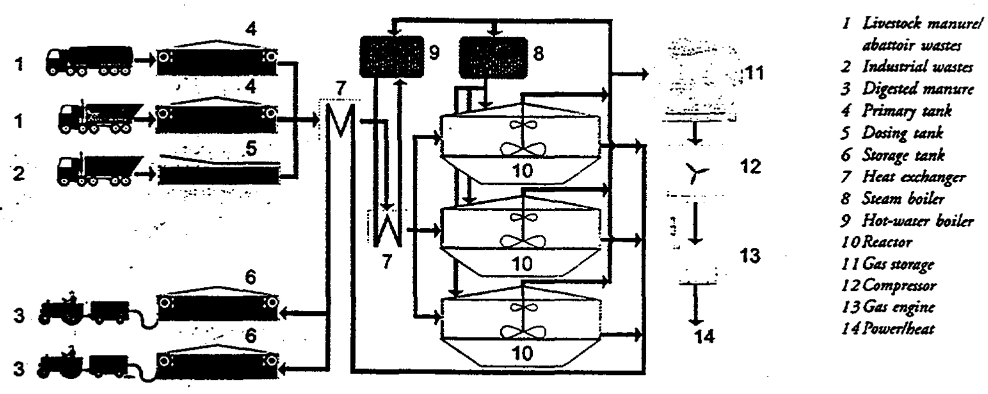
Reactor incl. insulation	145 - 200 US$/$m^3$.
Boiler	150 - 250 US$/kW

Plants with several households can supply a small gas grid or run a combustion engine for electricity generation. (See chapter for cogeneration.). It is also possible to heat water directly in the digester through a heat exchanger system.



Cross section of the advanced facultative pond showing both digesters, submerged gas collectors, sampling platform and bridge with details of the first digester and submerged gas collector.

Larger plants for organic waste from livestock manure, abattoir wastes and other organic wastes may have a capacity of several hundred tonnes of waste per day.
Investment cost: 700 - 2000 US$/m^3 reactor volume

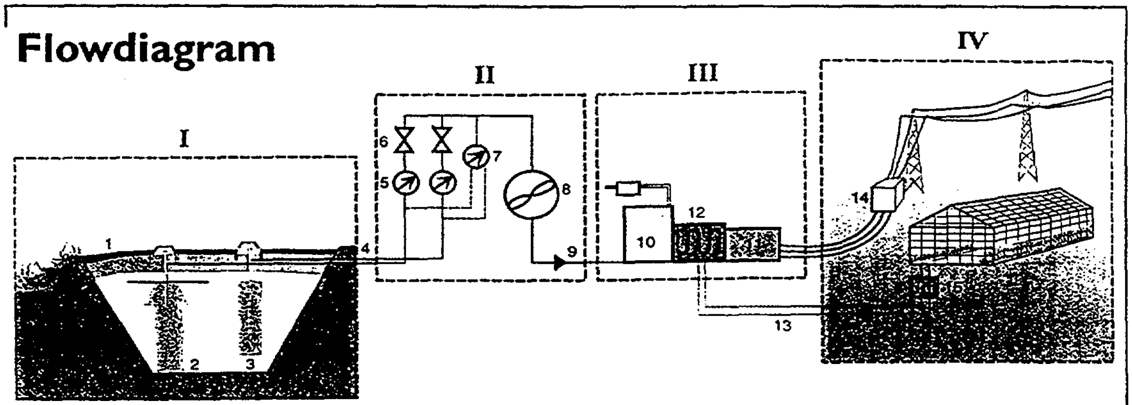


Ribe Biogas AS; largest biogasplant in Denmark; producing 12.000 m^3 biogas containing 55-65% methane daily, sent through a 2,5 km. long gas pipe to district heating station for producing heta and power by means of a gas engine. *(Krüger A/S)*

4.5 Landfill gas

The anaerobic digestion in landfills generates typically 40-55% CH_4, 25-40% CO_2, 5-15% N_2, 0-2% O_2 and 1% of other gases. Gas is extracted from the site through a series of gas wells drilled or digged into the deposit waste. For biogas utilisation the landfill or part of the landfill has to be closed and the depth of the landfill should be at least 4-5 m. To prevent air into the wells, a cover of i.e. 0,5-1,0 m sand is needed. Condensate and dust are removed from the biogas before it enters the power station. Gas engines produce electricity and heat or just heat in a gas burner.

In Norway the average specific cost for total investment for landfill gas utilisation have been 0,35 US$/kWh.. Specific cost for the energy utilisation was 0,14 US$/kWh.



I	*Landfill*	*1*	*Cover*	*6*	*Control valve*	*11*	*Generator*
II	*Regulating/pumping station*	*2*	*Fascine*	*7*	*Methane meter*	*12*	*Heat exchanger*
III	*Motor generator unit*	*3*	*Well*	*8*	*Blower*	*13*	*District heating pipe*
IV	*Energy recovery*	*4*	*Suction pipe*	*9*	*Pressure pipe*	*14*	*Transformer*
		5	*Flow meter*	*10*	*Gas motor*	*15*	*Heat exchanger*

The Dybdal landfill gas facility projetc in Denmark. Landfill 26.000 m^2 area and 15-25 m depth, total volume of 380.000 m^3 , generating gas 120 m^3/h , generator output of 170 kW electricity and and 280 kW heat. *(Krüger A/S)*

4.6 Cogeneration

Decentralised combined heat and power generation, CHP or cogeneration, is a very flexible and efficient way of utilising fuels of every kind of biomass. Such plants can be used in situations where a given heat demand exists; district heating, industry, institutions, etc.

By combining heat and power generation, the total thermal efficiency is typically more than 90%., generating 2/3 thermal energy and 1/3 electricity.

Cogeneration is possible by the following technologies:

- Steam engine
- Gas engine
- Steam turbine
- Gas turbine cycle for small scale biomass gasification
- Stirling engine

Steam engines are commercially available in the capacity range of 100-1500 kW.
Prices for the generator 2600 - 3100 US$/kW

Steam and gas turbines are generally for larger capacity ranges.
Prices for steam turbine total plant > 10 MW 4500 - 7000 US$/kW

Typical users for cogeneration plants are wood industry, pulp and paper plants, etc. - industry with biomass wastes and a demand for both heating and electricity. Plants for district heating and power generation in villages, towns and cities based on i.g. household wastes, biogas etc, are possible.

A comparison of small-scale cogenreation systems are showed below:

	Diesel engines	Gas turbines	Steam turbines
Fuel type	Biodiesel Biogas Landfill gas	Biogas	Any fuel
Capacity range	from 30 kWe	from 600 kWe	from 250 kWe
Heat/Power ration	1/1 to 2/1	2,5/1	from 3/1
Heat recovered as	Hot water 85 C	Medium grade steam	Steam
El generation efficiency (%)	35 - 40	20 - 25	< 20
Overall efficiency %	80 - 90	70 - 80	75 - 85

Stirling engines
The Stirling process has received renewed interest and may use any kind of fuel producing heat and power. There are several countries developing units for private homes and small scale industries. For the time being it is to early to give prices of investment and energyproduction.

References

1. The World Directory of Renewable Energy, Supplies and Services 1996. James & James 1996
2. Biomass for energy and the environment - proceedings of the 9th European Bioenergy Conference - Copenhagen June 1996
3. The Sustainable Energy Handbook - Associated Energy and Environment offices & The Danish organisation for Renewable Energy 1993
4. Perry's Chemical Engineers' Handbook, 6th edition.
5. Brochures and technical information from Krüger
6. Technical information from Energisystemer AS
7. Brochures and technical information from Ulstein Bergen AS
8. Brochures and technical information from Jøtul AS
9. Various CADDET technical brochures
10. Halm til energiformål, Videncenter for halm- og flisfyring , 1992
11. Small scale Cogeneration; CADDET analyses series 1, revised 1995

PHOTOVOLTAIC APPLICATIONS FOR RURAL AREAS IN THE NORTH-EAST EUROPE

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1 Introduction

Photovoltaic (PV) markets have grown in the EU by ca 25 % per year during the past decade. World-wide the production of photovoltaic cells has exceeded the 80 MW_p/yr limit. The costs of PV modules have dropped by a factor of 5 during the last ten years and is now at the level of 4-5 \$/W_p. The cost reductions mean on the hand new market segments for PV in the future.

Photovoltaic power systems are an attractive electricity source for stand-alone applications in remote areas. Especially in rural areas, PV may provide power to isolated villages or homes, telecommunication aids, etc. - basically the applications may range from individual to community scale.

Widely speaking, PV for rural areas has a tremendous potential world-wide as more than 2,000 million people are without any electricity services. Even in very urbanized regions such as South and Central Europe (EU12), more than 1 million people stood without electricity in 1988. North-East Europe is even a more promising target region for PV, as these territories are very scarcely populated, distances are large, and the electricity grid does not extend all over. As an example of niche-markets evolved through "north-east European ruralism", are the 30,000 PV solar home systems for recreational houses and cottages in the Finnish lake districts and archipelago. These systems are commercially fully justified even without any public support.

2 Markets for PV

It is estimated that the total PV installed world-wide is about 500 MWp (1996) of which less than 100 MWp is installed in Europe. Most of the PV applications are stand-alone systems, e.g. for rural energy applications (Figure 1). Most of the rural energy applications are simple home or village PV systems and these represent about 75% of the rural applications. About 60% of the PV rural energy applications are in developing countries and 40% in the developed countries.

The off-grid applications make some 90% of the world market - rural electrification alone represents 50-60% of the world PV module shipments. In Europe, the share of off-grids is somewhat smaller, or 78%, but still important. The share of small grid-connected systems in Europe has been a fast growing market sector mainly due to large public support programmes e.g. in Germany, Switzerland and the Netherlands.

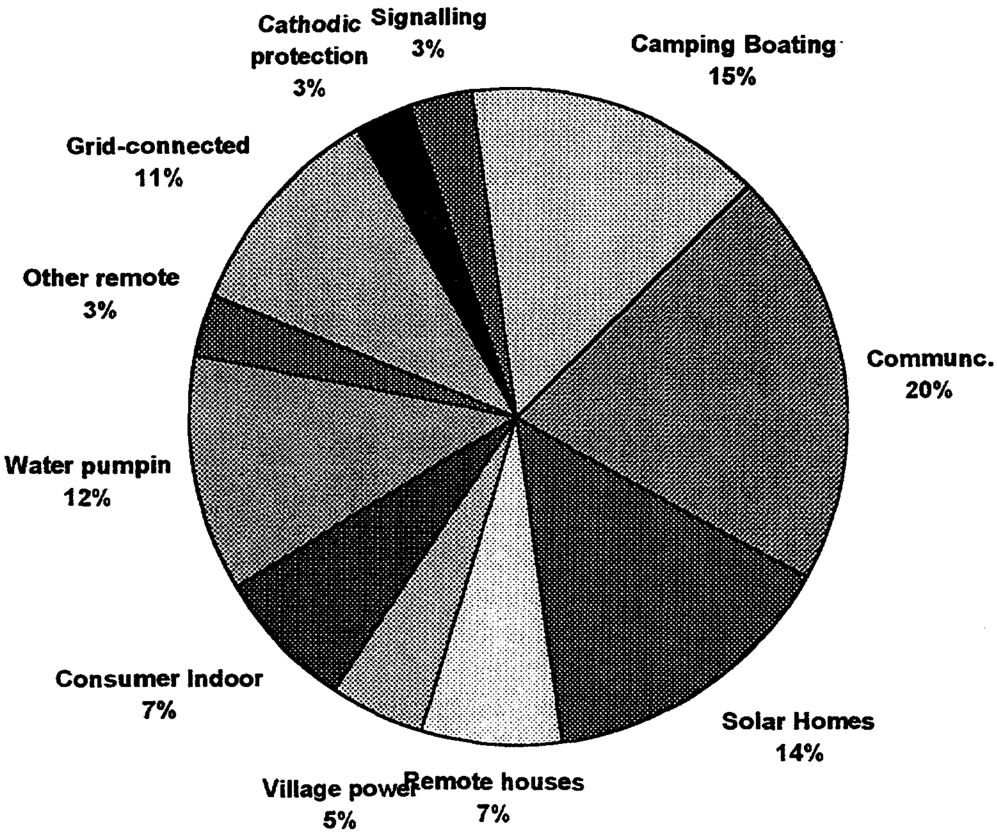


Figure 1. World PV markets by application.

The short- and medium-term market for stand-alone rural markets within the European Union (EU15) has been estimated to be some 150 MWp representing a total market value of 1-1.5 billion ECU. Most of this, or 75%, is in the northern part of EU, or, in the mountain regions of Central Europe.

The Baltic states and Russia may represent even a much larger potential as in Russia alone there is more than 30 million people in rural regions without electricity. A crude estimate of the market potential in these regions would be 300-500 MW_p , or in terms of market value, 3-5 billion ECU.

Priority markets for PV on a medium-term (up to year 2010) includes especially solar home systems. At present there is some 500,000 solar home systems world-wide.

3 Financial issues

Apart from wood for cooking, the domestic energy sources in rural regions are often kerosene and candles for lighting, and dry cells for radio. The energy expenses may reach $100-150 per year. Some 0.5 kWh/day of electricity may be considered a minimum level for basic needs.

The main part of the financing of a project may come from the money saved by replacing previous solutions such as:

- individual consumer needs : petrol, primary/secondary chemical batteries
- collective consumer needs: diesel, grid extensions

Important single issues for the competitiveness of PV include:

- reducing the electricity consumption through high efficiency appliances
- reducing the maintenance and management costs (simplified solar kits)
- public/international funding for conventional electrification should be also available for PV
- low-rate loans for financing private purchases
- duty-free PV appliances

4 PV system technology

The main PV systems for rural energy applications may be categorized into two major types: stand-alone and hybrid systems. The stand-alone systems involve PV modules, battery, and a controller; a hybrid system includes in addition an auxiliary power source e.g. a wind or a diesel generator in order to meet the load requirements all the time. If ac power is needed then an inverter need to be included.

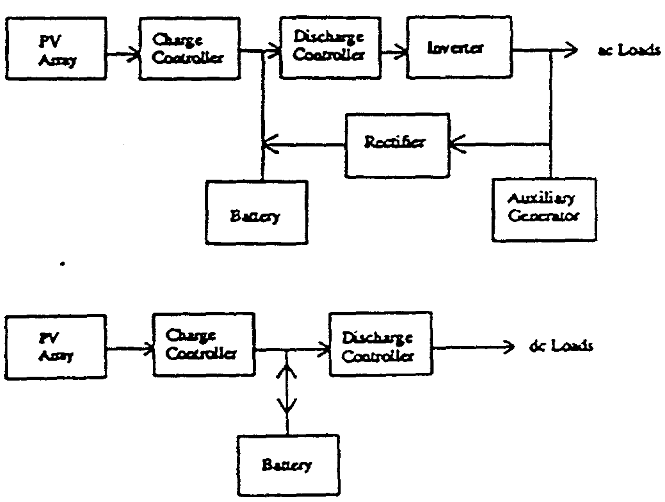


Figure 2. Principles of PV systems for rural energy applications.

In the next chapters, a few examples of more specific PV technology applications in rural areas are shown.

4.1 Solar lanterns

Solar lanterns represent a major improvement to kerosene lamps. The system consists of a small PV module (< 10 Wp), battery and a lamp. The lamp and battery are often integrated into one unit, but module can be placed a few meters from the lamp to optimize the solar availability during the day.

The price of the solar lantern is between $100-200 per unit. Major PV system houses such as Neste NAPS and Siemens Solar have solar lanterns in their product portfolio.

4.2 Solar home systems

A solar home system typically consists of a fixed PV module with a (car) battery, a battery charge regulator, 3-5 fluorescent lamps, wiring, and sockets for radio and television (Figure 3). This system is able to provide electricity for lighting and radio/television. Moreover, a solar home system has a grid-like image to many families.

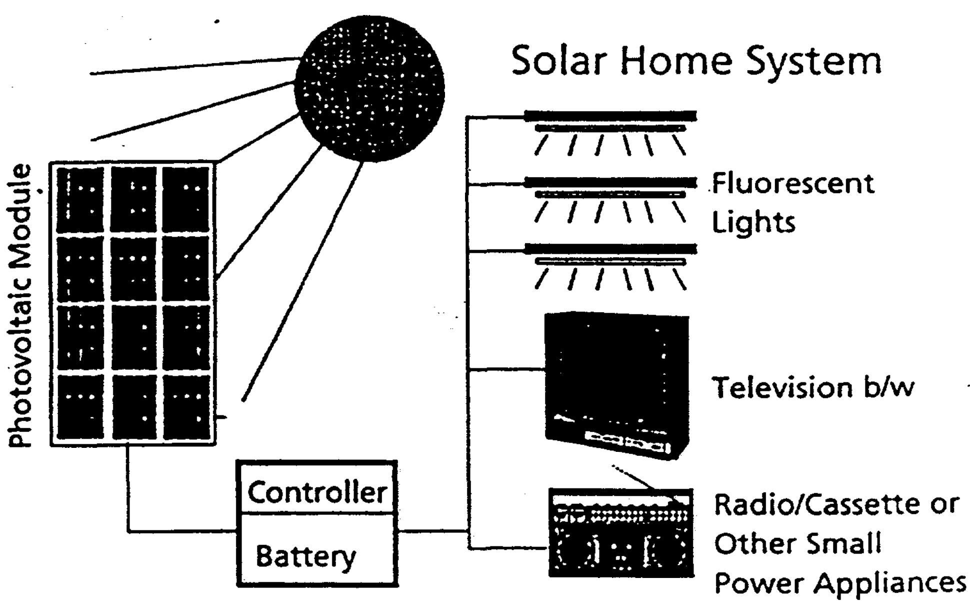


Figure 3. Solar home system.

The PV module is typically 40-50 Wp (equivalent to 80-120 Wh/day). In some cases, a smaller PV module may be purchased first and a larger module is added afterwards.

The cost of a solar home system may vary today between $400-1,500 depending on the size, taxes, duties and the share of local production of the components.

If say 50% of the value-added could be locally generated, then a price of $400-500 may be possible when 5,000-6,000 systems are delivered yearly (see Table 1). The system could be financed by the local purchaser through a leasing scheme where the user pays a downpayment of 35% of the total investment of $500 and monthly installments of around $10 over 3 years. For comparison, monthly costs for kerosene, dry batteries, candles may be in the non-solar case up to $20 per month. The cost of the 53 W system could vary between $425 and $1,500 depending on the local involvement. In case of north Europe, a commercial price around $1,000 is typical.

Table 1. Breakdown of costs of a solar home system.

	Cost ($)	Costs (%)
PV-module (53 W) and support	200	47
Battery (70 Ah)	40	9
Control	35	8
Lamps, wiring, switches	35	8
Delivery, installation, retail margins	75	18
Duties, taxes	40	10
TOTAL	425	100

4.3 Street lights

Street lights consist of a PV-powered light on a mounting pole with array, a battery and an automatic on/off-sensor to control the lamp. The lamps are normally 20-35 W and the array needed is 100-150 Wp.

Street lights are normally uncommon in rural areas, but may be very much prioritized for public buildings, meeting points, etc. The lights are visible from a few miles distance.

4.4 Telephones

Telephones are powered by a stand-alone PV systems coupled to a standard telephone radio link. Portable phones with PV may be very feasible for rural regions.

4.5 Small AC grid systems for villages

These systems consist of a small centralized PV generator with back-up generator, a battery system, DC-AC inverter and a local network which supplies energy to the houses. The minimum PV size is 1 kWp, but often such systems are up to 10-20 kWp. A village PV system is able to provide electricity also for appliances, machinery tools, etc.

4.6 Other applications

Other possible rural PV applications include:

- water pumping (drinking water or irrigation, PV 100-500 Wp)
- health centers (PV 300-1,500 Wp)
- battery charge stations (PV 500-1,000 Wp)

Battery charge stations may be interesting for rural communities. In this case, there is a common central PV station where the local homeowners may charge their batteries. This also close to a solar home system apart from that the batteries need to be transported. Central charging points provides an effective way of collecting fees. The main drawback is that batteries may be deepdischarged too much an the battery life-time may be very much reduced. In a solar home system, the battery controller takes care of optimum usage of the battery and thus provides a much longer life-time.

5 Basic system design

The basic PV system design may be split into two major parts: component selection and component sizing. These are described briefly in the following

5.1 Components

The components of a PV system are the following:

- PV array
- battery
- dc-ac inverter (optional)
- back-up power system (e.g. diesel generator, optional)
- control unit
- load

- cabling
- switches and fuses
- array structures

The most critical component from the operation point of view is the battery. A traditional lead-acid battery is sensitive to deep and overcharge and therefore a control-unit is needed (costs about $20-$40). Nickel-cadmium batteries have considerable better durability, but are somewhat more expensive. An important design consideration is the proper coupling of the PV-array and battery so that their (I-V)-curves coincide. A conventional PV-panel is normally sized for a 12 V battery.

The load and its time variation of the rural application has a major influence on the set-up of the whole system. Therefore it is of outmost importance to try to estimate these accurately before the final design of the system. Also, as PV is still rather expensive, it is important to minimize the loads. Table 2 shows typical power needs for dc-loads.

Table 2 . Typical DC-power loads.

source	power (W)	duration (hours/day)
watch	1	24
reading lamp	5-10	2
light	10-20	5
ventilator	20	
BW-TV	10-20	3
color-TV	40-60	3
radio	1-5	6
water pump	20-100	0,1-0,5
refrigerator	10-100	8-10

If household appliances are to be supplied through PV, it may be worthwhile to consider the use of DC appliances as these consume only 1/3 of the electricity of corresponding AC-appliances (Table 3).

For cabling, a 1 mm2 cable is recommended for 10 A PV currents, 4 mm2 for 30 A, and 10 mm2 for 50 A.

Table 3. Comparison of electricity consumption of a solar DC home with a traditional house with 220 V appliances

	Daily Consumption	Daily Consumption
	Solar DC	Average AC 220 V
Lights (6 bulbs, 3h/d)	220 Wh/day	1100 Wh/day
Refrigerator (300 liters)	360	1200
Freezer (300 liters)	760	1900
Color TV (8 h/d)	360	800
TOTAL	1700 Wh/day	5000 Wh/day

5.2 PV output

The PV electricity output depends very much on the site and the weather conditions. In north and north-east Europe, most of the solar radiation that drives the PV system comes during the summertime, but winter the radiation available is very small. As general rule for north-east Europe, one may estimate the amount of solar radiation between 800 and 1100 kWh/m2; the difference between summer and winter is a factor of 20 (Figure 4).

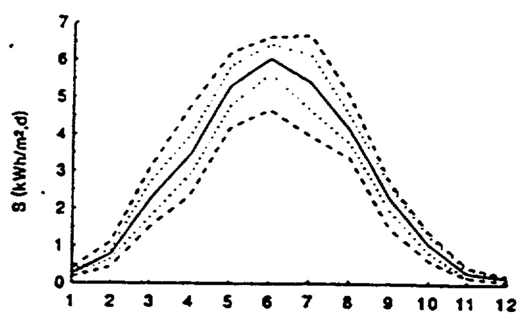


Figure 4. Solar radiation on a horizontal surface in Helsinki (60 N). The solid line is monthly average radiation, the dotted lines are the standard deviation and the broken lines are the extremes observed.

Through inclining the PV panel, the monthly distribution of solar radiation on the panel can be influenced. The optimum inclination angle is the latitude±15-30 deg; for winter time 60-90 deg is optimum and 20-30 deg for summer, respectively. If the angle is fixed, then an inclination of 40-45 deg gives the maximum over the year.

The dc-electricity output of the PV panel is in north-east Europe about 800-1000 Wh/Wp. For instance, a single 53 W panel provides thus about 40-50 kWh/yr. The system efficiency is normally between 60-80% which means that the net useful electricity obtained is some 450-800 Wh/Wp.

For system sizing, it may be necessary to know the monthly distribution of solar radiation and PV output. Table 4 gives a few examples for north-east Europe of the extreme conditions. For example, a 53 W PV panel produces in average in a 55 deg N site in December/January about 42 Wh/day, but in a 62 deg N site only 21 Wh/day. In June/July, the production numbers are 312 Wh/day.

Table 4. Average daily solar radiation available on a 45 deg inclined surface in north-east Europe (kWh/m2,day)

Site	January	June
55 deg N	0.8	5.9
60 deg N	0.5	6.3
62 deg N	0.4	5.9
68 deg N	0.1	5.5

5.3 System sizing

The system sizing comprises normally the selection of the PV-array size, battery size and back-up power so that the load can be met most economically.

The steps of the sizing are the following:

1. define all loads, their power and duration
2. define average load for each month (Wh/day)
3. estimate the solar radiation available for each month (or extreme conditions, e.g. from Table 4)
4. determine the corresponding PV power needed for each month (load/ {system efficiency × radiation})
5. estimate the battery capacity needed (maximum daily electricity requirement × supply time/maximum discharge level)

Figure 5 shows some crude estimates for rural PV-battery system sizing in north- and north-east Europe. One PV module corresponds to about 50 W and one battery to 600-1000 Wh, respectively. The lower curve is for ca 55 deg N and the higher curve for 68 deg N - other latitudes are covered by the region inbetween the two curves. In addition, in Table 5 we have provided statistical "correction factors" for system sizing in respect to the reliability requirement. The solar home systems are covered by "medium" and professional applications by "high".

Table 5 . Statistical correction factors to PV-battery sizing.

season	inclination (deg)	system availability	correction factor for PV panel size	storage capacity (days)
summer	30-45	medium high	1.2-1.5 1.3-1.6	3-5 8-12
spring/ autumn	45-60	medium high	1.3-1.6 1.4-1.8	8-12 20-30
winter	60-90	medium high	1.4-1.8 1.5-2.0	15-25 45-60

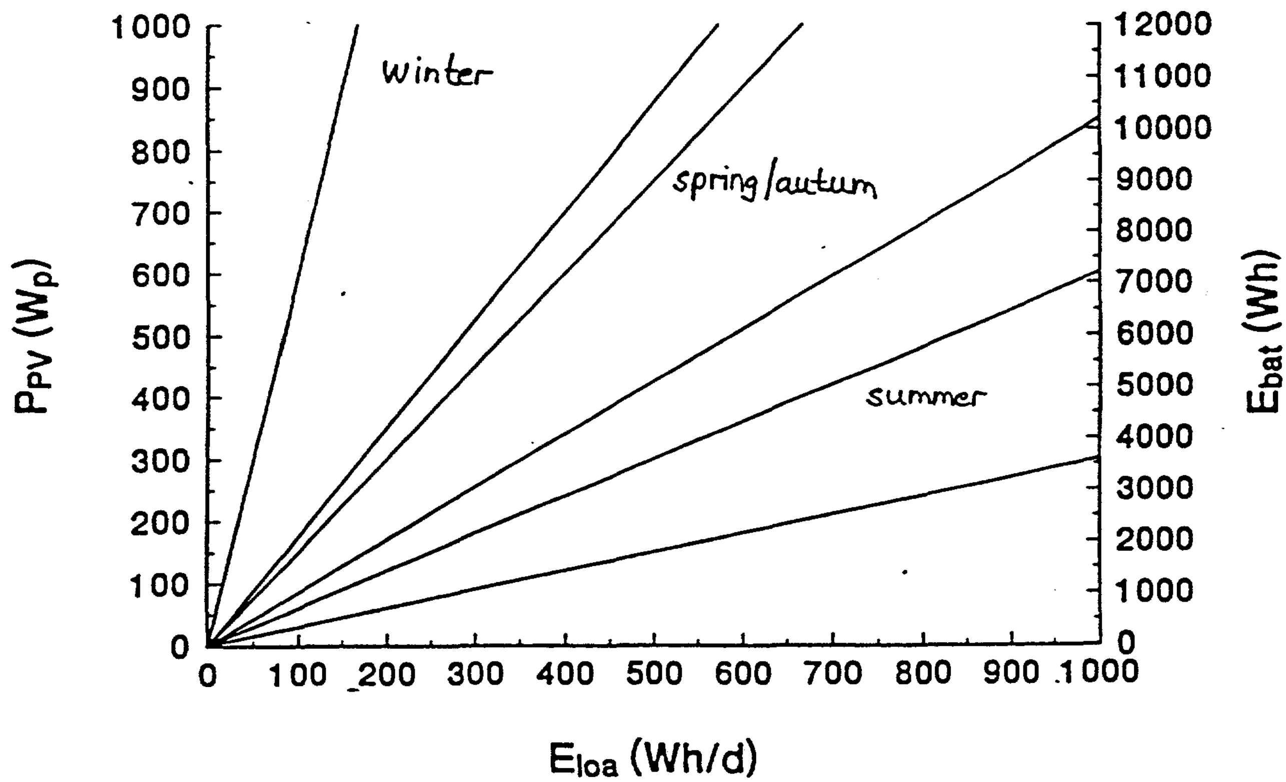


Figure 5. Guidelines for sizing the PV-battery system in north- and north-east Europe. The battery is a deep-discharge battery (DODmax=80%). Ppv=PV panel power, Ebat=battery capacity, Eloa=average daily load.

6 Examples of typical projects

Finally, some realized PV projects that could applied in the rural renewable energy context in north-east Europe are shown in the Appendix. These include:

- navigation lights in Finland
- summer cottage PV systems in Finland
- house boats in Canada
- rural electrification with solar home PV (NL)

References

European Commission (1996). Photovoltaic in 2010. Luxembourg.

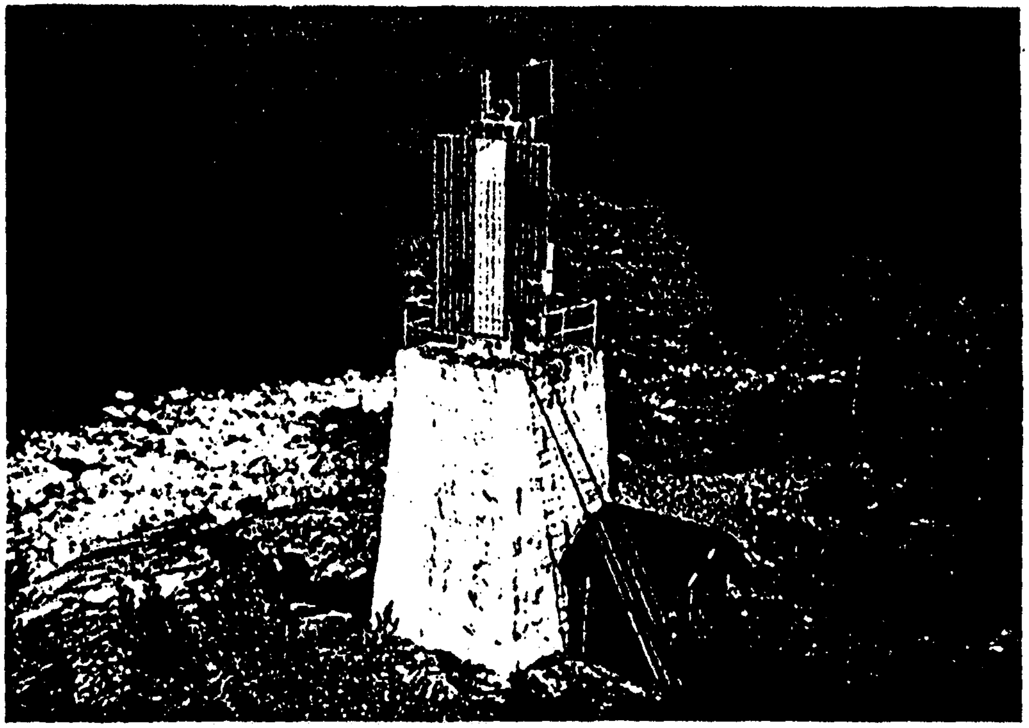
International Energy Agency (1995). Examples of stand-alone photovoltaic systems. James and James.

Peippo, K. (1992). Sizing of PV systems. Helsinki University of Technology. NEMO-report 23.

Appendix: Examples of stand-alone PV systems

Navigation Lights

Finland, Commercial



Purpose:

Electrification of navigational lights.

Advantages:

Autonomous, no auxiliary power source required. Least cost solution due to low maintenance requirements.

General remark:

Vented NiCd batteries were found suitable for this application.

Market		Finance		System	
Region	Finland	User group	National Board of Navigation	Array size	50 Wp
Position	Along the coastline	Investment by	By the National Board of Navigation, no subsidies	Battery size	12 V 70 Ah NiCd
Items installed	1 600	Cost of product	US$ 1 400 (estimate)	Demand	4–10 Wh/day
Potential in region	–	Cost of PV components	–	MTBF	–
Potential world-wide	–	PV cost fraction	–	System type	Stationary, Remote/off-grid
		Distance to the grid	Typically more than 5 km	Aux. Sources	None
		Pay back time	–	Applied since	1982

Contact : National Board of Navigation: Merenkulkuhallitus, Turvalaitetoimisto P.O.B. 158, FIN-00141 Helsinki, Finland,
Phone: +358 0 180 8318, Fax: +358 0 180 8470

Houseboats

Canada, Commercial

Purpose:

Provides power as needed for lighting, communication, water pumping, small appliances, etc.

Advantages:

Continuous power supply off-grid. Cost effective, reasonable payback time. Quiet; reduced fossil fuel consumption; maintenance free. Environmentally safe; user friendly.

General remark:

Systems may be sized up or down to accommodate a variety of needs depending on number of inhabitants. Generally used as a hybrid system (diesel or gas generator for back-up charging in winter and for some larger loads). Homes used year round.

Market		Finance		System	
Region	Northern Canada	User group	Houseboat owners	Array size	150 – 300 W
Position	60°N, 115°W	Investment by	Houseboat owners	Battery size	440 – 660 Ah / 12 V
Items installed	10	Cost of product	US$ 2 000 – 3 500	Demand	1 200 Wh/day (summer)
					2 400 – 4 800 Wh/day (winter)
Potential in region	50	Cost of PV components	US$ 600 – 1 200	MTBF	5 years (due to batteries)
Potential world-wide	–	PV cost fraction	30%	System type	Mobile, Remote
		Distance to the grid	over 0.5 km	Aux. Sources	Diesel or gas generator
		Pay back time	2–4 years	Applied since	1989

Contact Midnight Sun Energy Systems, Box 1683, Yellowknife, Northwest Territories, XIA 2P3, Canada.
Phone: (1) 403-873-8760, Fax: (1) 403-873-8768

Summer Cottages: Small Applications

Finland, Commercial

Purpose:

Electrification of remote summer houses with small loads.

Advantages:

Cost-effective, autonomous, reliable, no pollution or noise.

General remark:

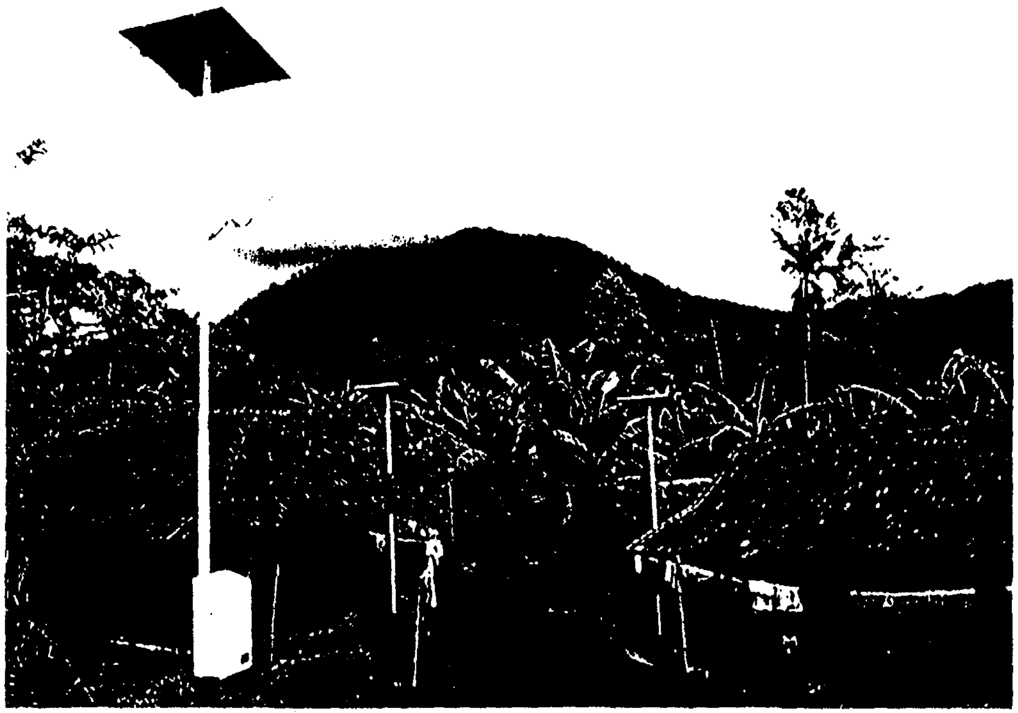
The grid is not available in most cases.

Market		Finance		System	
Region	Finland	User group	Private	Array size	50 Wp typically
Position	Mainly central and southern Finland	Investment by	By users, no subsidies	Battery size	12 V / 120 Ah
Items installed	16,000 – 20,000 (total)	Cost of product	US$ 1 200 complete system	Demand	130 Wh/day, mainly summertime
Potential in region	–	Cost of PV components	–	MTBF	–
Potential world-wide	–	PV cost fraction	–	System type	Stationary, Remote
		Distance to the grid	Typically more than 5 km	Aux. Sources	None
		Pay back time	–	Applied since	1985

Contact : Neste Advanced Power Systems International, P.O.B. 3, FIN-02151 Espoo, Finland,
Phone: +358 0 4501, Fax: +358 0 450 5744

Rural Electrification by PV Solar Home Systems

The Netherlands, Market Potential



Purpose:

Providing remote areas with electricity for houses, workshops, shops and streetlighting.

Advantages:

Economically acceptable electrification of remote villages.

General remark:

The SHS comprises a regulator, a battery and a support construction for the module to supply three 6W TL lamps, a 20W TV, an 8W radio The user pays for the SHS in monthly payments of US$ 5.

Market		Finance		System	
Region	Lebak, West Java	User group	Villagers	Array size	48 Wp
Position	52°N, 5°E, sea level	Investment by	Provincial government of North-Holland: US$ 50,000, utility company (PEN) US$ 100,000	Battery size	105 Ah, 12 V
Items installed	500 SHS in 1991, 1 000 SHS in 1994	Cost of product	US$ 500	Demand	130 Wh/day
Potential in region	–	Cost of PV components	–	MTBF	>3 yrs
Potential world-wide	All developing countries, ca. 2 billion people	PV cost fraction	–	System type	Stationary, Remote
		Distance to the grid	–	Aux. Sources	None
		Pay back time	–	Applied since	1990

Contact R&S Renewable Energy Systems B.V., P.O.Box 3049, 5700 JC Helmond, Lagedijk 26 5705 BZ Helmond, The Netherlands,
Phone (31) 492-523335, Fax: (31) 492-549665, Telex 59030 res nl

BUSINESS FORUM

Arbeitsg meinschaft
ERNEUER ARE ENERGIE
A-8200 Gleisdorf, rtengasse 5, Postfach 142
STRIA

Profile

Type of Association

Scientific non-profit-making organisation with its head office in:
A-8200 Gleisdorf, Gartengasse 5, Austria
Tel.: +43-3112-5886-0; Fax.: +43-3112-5886-18
e-mail: arge-ee-gl@sime.com

Staff

14 employees
5 -10 specialised staff, working as free-lancers or on a contract basis

Co-operating Partners

Technical University Graz
Technical University Vienna
University of Graz
Joanneum Research, Graz
Institute for Solar Energy Research(ISFH), Hameln, Germany
Frauenhof Institute for Solar Energy Systems, Freiburg, Germany
SOLPROS AY, Helsinki, Finland
KANENERI AS, Rud, Norway
Domestic Solar Heating Ltd. Harare, Zimbabwe

Clients

European Union
Federal Ministry of Science and Research
Federal Ministry of the Environment
Austrian Energy Agency
Styrian Provincial Government

Municipality of Villach
Municipality of Graz

Our Scope of Work

We specialise in carrying out consultations, instruction, research and planning work in the following fields: the use of solar energy for hot-water and heating purposes, translucent thermal insulation, integrated roof systems for photovoltaic modules, communal energy concepts, biological sewage purification, utilisation of biological substances and training work.

Thermal Solar Plants

Apart from the 25,000 solar hot-water units, which have been erected in assembly groups supervised by us, we have also been able to carry out several larger solar plants for heating purposes. These plants in particular have shown us that the possibilities in this field have been under-estimated in the past. By the construction of houses with a high standard of thermal insulation in connection with solar thermal plants, it has been possible to reach a degree of solar coverage for hot-water and heating of more than 50 %.

Transparent Insulation

Improvements in the conventional insulation only lead to a reduction of the transmission heat loss of a building, but the use of this new highly translucent insulation material has shown that the heat loss is compensated for by the solar energy won. Furthermore, it is possible to use the solar energy won to heat buildings. Experience in Germany proves that a translucent thermal insulation facade, together with other measures, can result in an 80 % reduction of the heating energy requirement.
One of the main distinguishes of this transparent insulation is the high coefficient of permeability for sunbeams and another is the good insulating properties. Depending on the positioned direction, type of wall and the dimensions of the transparent insulation facade, it is possible to achieve savings in the energy consumption of 100 to 200 kWh per m^2 of translucent thermal area.
This new heating system was installed in the office building of the "Feistritzwerke Gleisdorf" as part of its total renovation and was the first building in Austria to be heated with solar energy. Part of the Southwest facade was covered with translucent thermal insulation. This was the first actual realisation of the study commissioned by the Federal Ministry and Provincial Energy Association of Styria.

Solar Electricity from the Roof

The acceptance of solar plants by the population depends to a great extent on the optical blending in with the architecture. From the positive experiences gained from the roof integration of thermal plants, it was obvious that it was also necessary to develop a roof integration system for the photo-voltaic modules.
We erected one of the three Austrian demonstration buildings included in the Solar-Heating and Cooling Programme (TASK 16) of the International Energy Agency.

Biological Substances – also a product of the sun

In the field of the utilisation of biological substances, the centre of our attention is not only in providing consultation on how to use piece and chopped material for firing plants with a small capacity, but also in examining the possibilities of the use of energy grass (Miscanthus sinensis "Giganteus"), to obtain energy.
Miscanthus sinensis "Giganteus" is a perennial C4-plant and can be used for firing, vaporisation, as a liquefying agent and in the production of cellulose. In the future this could be an interesting market for the agricultural industry, as yearly dry substance yields of 25 to 30 tons per hectare can be achieved.
In 1989 the Arbeitsgemeinschaft ERNEUERBARE ENERGIE started its experiments in this field with the planting and taking care of test plants in Hitzendorf near Graz. The next stage followed in the Spring of 1991, the STEWEAG commissioned further test areas amounting to 2 hectares. The developments of these plants are analysed and documented in an extensive research programme.

Natural Sewage Purification

Our most important natural raw material – WATER – is in danger. We consume far too much and channel the water, polluted from excrements, chemicals and toxic substances, back into our environment. The use of conventional sewage plants to cleanse the water has resulted in the dehydration of large parts of the country and in careless handling of our precious substance water. Furthermore, the construction of large sewage plants increasingly borders on social and ecological limits.
Botanical sewage plants, providing they are set up correctly, can make a substantial contribution to clean sewage water in countryside areas. The owners of botanical sewage plants are more conscious about natural resources. For this reason Arbeitsgemeinschaft ERNEUERBARE ENERGIE offers seminars and assembly courses to provide the necessary know-how to build such botanical sewage plants.
The widespread interest in these methods of sewage purification, that are close to nature and also carefully handle natural resources, has been underlined by the increasing number of such plants built over the past years and also by the numbers of participants in our courses and enquiries from citizens, in particular from representatives of communal groups.

Training and Instruction Work

One of our most important activities is our journal "erneuerbare energie". It is the only technical journal in Austria, reporting solely about renewable types of energy. Each edition has a focal point, e.g. newest developments, up to date technology, and also presents experiences from internationally accepted specialists.
At conventions, seminars and field trips, we pass on our knowledge and the results obtained from all of our fields of work, as well as all other comprehensive information relating to renewable energy, to instructors, planners, performing companies and interested parties.
We invite guest speakers from the world of science and scientific research and also experienced practitioners to our functions.
We would be very happy to send you, free of charge, our seminar programme and a list of publications available from our mail order.

Where do we come from ?

The Arbeitsgemeinschaft ERNEUERBARE ENERGIE is an independent public welfare association, aiming to promote and support the meaningful use of renewable sources of energy and the efficient durable use of energy. The association was founded in Gleisdorf (Styria) in 1988 and over the past years has spread its field of activity to include the whole Province.

The fundamental idea of the Arbeitsgemeinschaft ERNEUERBARE ENERGIE is the self-assembly of solar plants. The first self-assembly group initiated in 1983 has since developed into a movement, active in the whole of Austria. The number of members has increased constantly and at present there are about 6,000 members.

Since 1989 the self-assembly systems have been continually developed and with the support of the Federal Ministry for Environmental, Youth and Family Affairs, the organisation of a consultation service for the whole of Austria has been worked out. Today there are departments or even branches of the association operating in every Province, apart from Upper Austria. Parallel to our activities in Austria, it has also been possible to propagate our assembly system to the neighbouring countries Germany, Switzerland, Italy, Czech Republic, Slovenia and Hungary. Up to the end of 1995, about 270,000 m^2 surface area of solar panels were assembled according to our system in Austria.

Who are we and want are our goals ?

The main goal of our ten full-time employees and of our numerous free-lance and honorary assistants is to work out comprehensive strategies in order to establish solar technology, as quickly and as widespread as possible, as the basis for an ecologically acceptable energy supply for the future. The number of people, who are not prepared to wait for our Government to produce an ecologically acceptable energy supply concept, is increasing steadily. The Arbeitsgemeinschaft ERNEUERBARE ENERGIE is trying to activate this group. Our work is not only of theory with studies and reports, we also show the numerous possibilities to actually apply the theory and to offer our services to help carry out projects.

SOLPROS

TRANSFER OF SCIENCE INTO PRACTICE

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Company profile

SOLPROS AY is an independent Finnish company established in 1994/95 to enchance transfer of science into practice (Appendix 1). SOLPROS works on energy, environmental, and health issues in the built environment and operates in an international framework. SOLPROS provides advising to different problem solvings, sophisticated engineering tools and consulting services.

SOLPROS supplies a range of customer-orientated services and can provide with:

- feasibility studies and system predesigns
- advanced simulation and computer programs
- technology-transfer, dissemination and project management assistance
- strategic planning and market penetration analysis
- technology and programme evaluations
- analysis of environmental and health impacts

SOLPROS tasks are mainly focused into the following technical areas:

- renewable energy systems (solar thermal, PV, energy storage)
- building energy conservation
- low energy technologies
- numerical modelling and computer tools
- environmental medicine

SOLPROS has capabilities of dealing with sophisticated multi-disciplinary questions ranging from overviews to technical details. SOLPROS brings together many skills for the benefit of customers.

Selected activities 1995-97

Recent dissemination, advising and consulting activities (1995-97) have included e.g. the following projects with corresponding contracting parties:

- Analysis on thermal pollution dispersion from waste heat storage in groundwater (SBL, Austria)
- Health and environmental analyses of ground water systems and aquifer storage (Monbusho International Scientific Research Program, Japan)
- Market study on solar thermal applications in Finland (subcontract to Esbensen Consultants, Denmark, EU-Thermie B)
- Energy conservation strategy in Estonia (subcontract to Uniscience Ltd., Finland, EU-Phare)

- State-of-the-art review on solar thermal energy storage
(Swiss Federal Office of Energy)
- Training course solar water heating-Latvia, Baltic States
(EU-Thermie B)
- Evaluation of the Swedish programme for energy conservation 1991-1996
(NUTEK, Sweden)
- Background analyses on new renewable energy sources and energy conservation for the New Energy Policy Strategy of the Finnish Government
(Ministry of Trade and Industry, Finland)

The activities in design tools have been focused on the dissemination of two in-house developed computer design tools EUROSOL© for solar heating systems and SOLCHIPS© for seasonal storage systems (Appendix 2). These tools are now used world-wide in nine countries among designers, manufacturers and researchers.

PUBLICATIONS

Heidrun Faninger-Lund: Basic health aspects on the human intervention in aquifers in connection with elevated temperature levels. June 1995, Japan. 9 pages.

EUROSOL© 2.0: Manual to simulation program for solar heating systems. Helsinki, 1996.

H.Faninger-Lund: A Process Heat Solar Project. IEA Workshop on Large-Scale Solar Heating. Vienna, October 5-7, 1995. 4 pages.

Heidrun Faninger-Lund: Non-technical issues of solar energy systems. Economics and Environment. Proc. of 5th Int. Summer School Solar Energy. Klagenfurt, 1996. 4 pages.

Heidrun Faninger-Lund: Training course for solar water heating held in Riga. Latvian Energy News, July-August 1996, Issue 21. page 3.

Peter Lund and Heidrun Faninger-Lund: State-of-the-Art Report on Advanced Solar Thermal Storage Systems. Swiss Federal Office of Energy. August 1996. 45 pages.

Peter Lund et al: Evaluation of the NUTEK's programme for effective energy use. Report NUTEK R 1996:68. 120 pages.

SOLPROS
TRANSFER OF SCIENCE INTO PRACTICE

Appendix 1 **COMPANY HISTORY**

The founders and partners of SOLPROS are Dr. Heidrun Faninger-Lund and Prof. Peter Lund.

Heidrun Faninger-Lund is Doctor of Medicine from the University of Vienna. She is also managing director of SOLPROS and is responsible for environmental and health related questions of energy systems. Special areas include environmental medicine.

Peter Lund is Doctor of Technology from Helsinki University of Technology and has aquired supplement education at London Business School. He is Associate Professor in advanced energy systems at Helsinki University of Technology. He is technical adviser for SOLPROS on energy and simulation questions. He has wide experience in international cooperation, strategic issues and he has published widely in professional journals.

The company was established in 1994 and adapted its present activities in late 1995. The company works on an international basis. The leading idea in SOLPROS is to enhance the transfer of scientific knowledge and results into practical ideas and use.

SOLPROS has a staff of 2 experts and other experts on project basis.

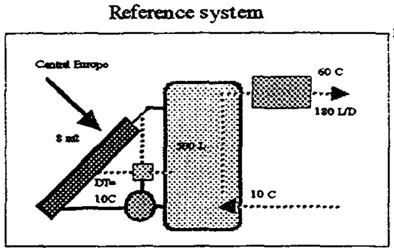
Appendix 2 SIMULATION PROGRAMS

SOLPROS provides with in-house developed simulation programs for solar energy and energy storage systems. These products are based on high scientific sophistication outgoing from customer needs and maintaining at the same time user-friendliness. The SOLPROS simulation products include several unique features and algorithms. The results from the programs have been verified with good agreement. SOLPROS programs include:

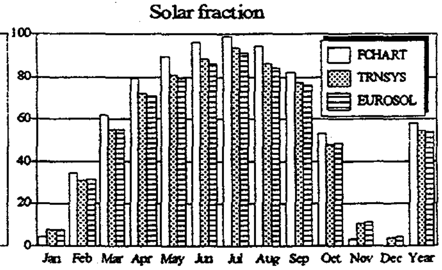
- **EUROSOL©**
  - user-orientated simulation program for solar heating and solar water systems
  - special attention on different thermal storage concepts and system control
  - applicable for residential and commercial systems, district heating
- **SOLCHIPS©**
  - computer tool for predesign and sizing of solar systems with seasonal storage
  - finds optimum collector area and storage volume for a system configuration
  - includes most available storage techniques and in-built cost functions
- **EUROWEA©**
  - simulation program for generating hourly synthetic weather data
  - main input monthly average solar radiation and outdoor temperature
  - produces from total radiation data direct and diffuse components

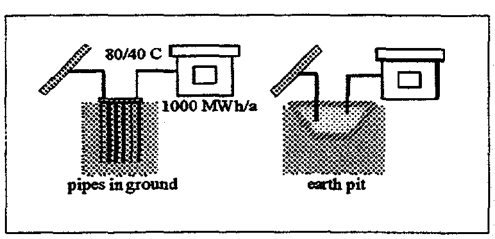
Examples of EUROSOL© and SOLCHIPS©:

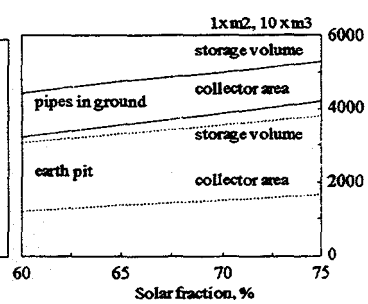
Reference system



Solar fraction







Other services available from SOLPROS include predesign simulations of photovoltaic systems and 3-dimensional analysis of heat transfer in ground (e.g. ground heat pumps, heat storage in ground water).

KanEnergi

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Bank: 6228.05.59046
NO: 965962964

Brief Company Profile

KanEnergi AS is an independent consulting company established in 1993. KanEnergi AS, and since 1997 it's associated company in Sweden, KanEnergi AB, are working in the field of energy and the environment. Much of the present work is on renewable energy and energy efficient technologies. Our key competence areas are:

- Solar energy
- Bio energy
- Wind energy
- Wave energy
- Market analysis
- Environmental monitoring and assessment
- Heat pumps
- Wood drying
- Energy efficiency
- Demand side management
- Integrated resource & least cost planning
- Life Cycle Assessment

KanEnergi AS has international experience in both industrial and developing countries. Our reference list covers policy development and evaluation, programme administration, technology evaluation, feasibility studies and techno economic follow up. Current main tasks include government programme administration, energy planning and energy resource assessment.
KanEnergi AS has seven experts with more than 80 years of relevant experience, all with a university degree or equivalent.

Selected projects and the corresponding contracting parties:

• Renewable Energy for Electricity Generation in Chile.	Det Norske Veritas/UNDP
• Managing the Norwegian introduction programme for energy efficient technologies.	Norwegian Water Resources and Energy Administration (NVE)
• Managing the Norwegian R&D Programme "Efficient and Renewable Energy Technologies".	Norwegian Research Council
• Responsible for the Norwegian participation of the IEA CADDET Programme (Centre for Analysis and Dissemination of Demonstrated Energy Technologies).	Norwegian Water Resources and Energy Administration (NVE)
• Evaluation of JOULE and Thermie projects.	Norwegian Research Council /EU-Commision
• Development of a proposal for a Norwegian R&D programme for technologies for reducing greenhouse gas emission.	Norwegian Research Council
• Biofuels for transportation.	Norwegian Water Resources and Energy Administration (NVE)
• Evaluation of the Finnish R&D programme "NEMO2".	TEKES, Finland
• Feasibility study : Introduction of bioenergy in the county of Hordaland.	The County Governor of Hordaland County


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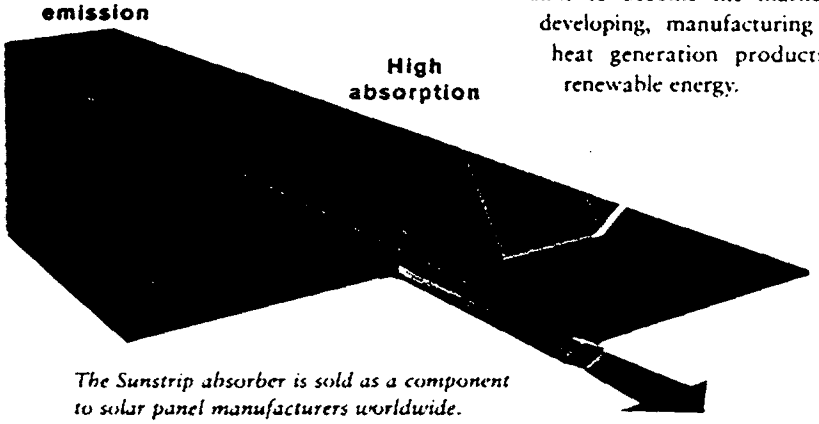
– the most reliable strip in Europe

Heating systems



The Sunstrip absorber is sold as a component to solar panel manufacturers worldwide.

Business concept

The TeknoTerm Heating Systems division aims to become the market leader by developing, manufacturing and selling heat generation products based on renewable energy.

Renewable energy

The accumulation tank is the heart of the system. It supplies the house with both heat and hot water and is adapted to all types of energy sources.

If you link the accumulation tank to solar heating you can satisfy your hot water requirements during the summer combined with added heat. You will also save both money and the environment.

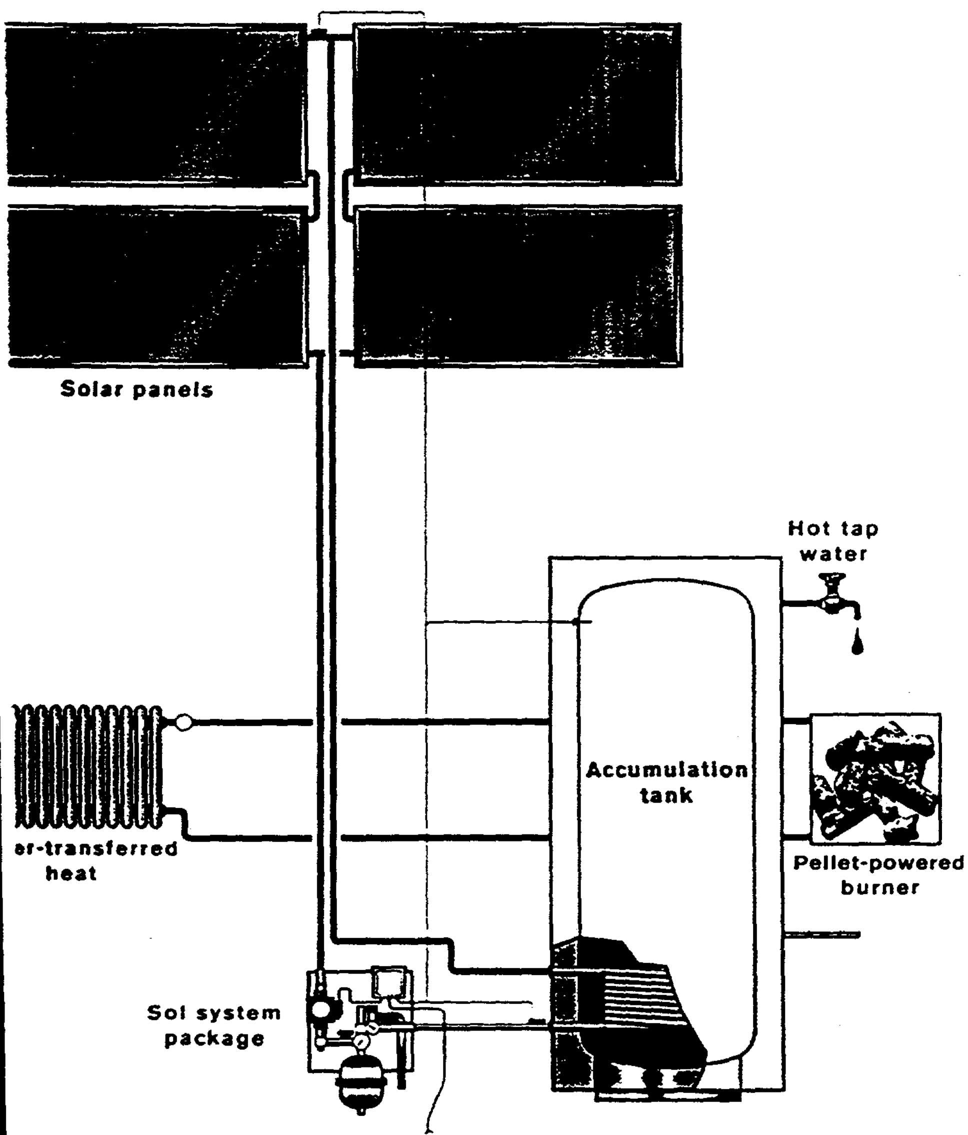
During the winter, when heating requirements are at their peak, the pellet-powered burner can be brought into operation to halve the heating costs. A reassuring thought when faced with the risk of future rises in the price of electricity and oil.

Component sales

Developing new products is expensive. For this reason we sell high-class components to other manufacturers and we purchase quality components from them. This ensures that the customers always have the best products on the market. Sunstrip, our absorber, is used by many of the major solar panel manufacturers in the world.

Quality

To guarantee our customers' safety we have our own ongoing internal quality control procedures. We also continually engage the services of independent international test institutes to monitor our production. The products that leave our factory are of the highest quality and manufacturing processes are in compliance with ISO 9002.

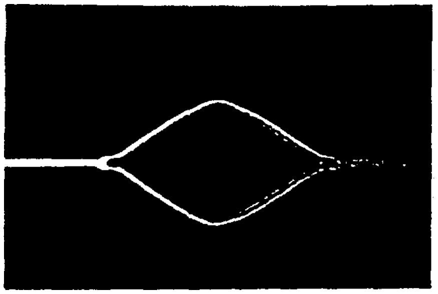


The heating system of the future is based on renewable energy: Solar panel + Accumulation tank + Pellet-powered burner.

Our products

- **Accumulation tanks**
- **Solar panels**
- **Pellet-powered burners**
- **Sunstrips**
- **Absorbers**
- **Control equipment**
- **Brine** (heat transfer medium)

Indoor climate



Cross-section of a water channel in the cooling baffle - TeknoTerm's world patent.

Business concept

The TeknoTerm Indoor Climate division aims to become the market leader by developing, manufacturing and selling cooling, heating and ventilation products to create a good room climate.

Which customer problems do we solve?

As the name suggests, the division specialises in indoor climate regulation, involving heating, cooling and ventilation of commercial premises such as offices, hotels and conference centres.

Our products enable us to adjust the temperature in each room easily and rapidly. It is also possible to modify the climate to suit individual wishes without needing to call in experts.

The products are adapted to the strict demands for a low noise level, absence of draughts and hygiene. The products are both light and simple to install in existing buildings or new constructions.

Function

Cooling a room entails channelling away excess heat using cold water and heating the room through heat radiation.

The system has no moving parts in the room, operating costs are low and the system has a long life span. Compared with air-transferred systems, space requirements and investment costs are lower.

The products have smooth, easily accessible surfaces, which means that they are ideally suited for use in areas where hygiene is vital, such as hospitals.

As the energy transfer medium is water, it is possible to use the heating or cooling source that is most appropriate. The system is adapted to future demands for environmentally friendly energy production.

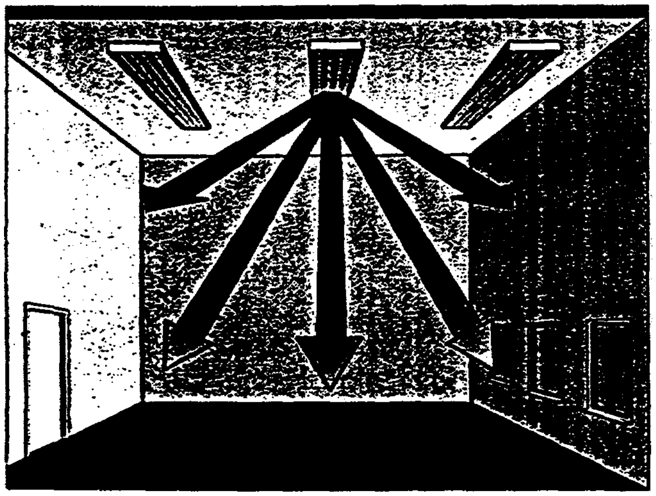
Quality

TeknoTerm products are of the highest quality and are tested regularly by SP, the Swedish National Testing and Research Institute. For our customers' safety and peace of mind we continually carry out quality controls in compliance with ISO 9002.

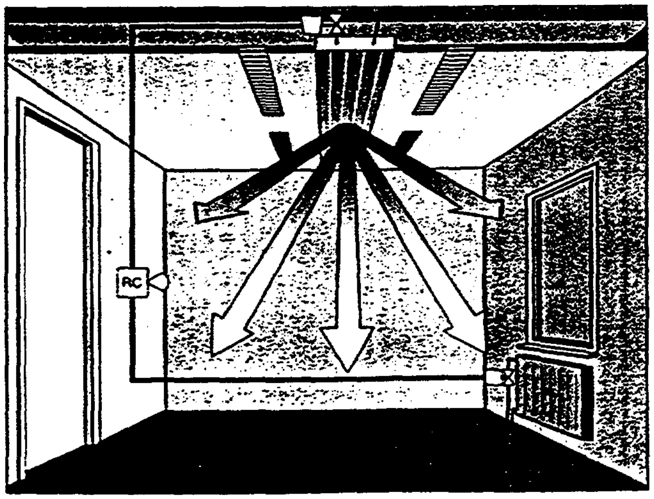
A good indoor climate demands a high standard of hygiene. Here we see a mite enlarged approximately 200 times.

Our products

- **Radiant heating strip**
- **Cooling and heating panels**
- **Chilled beams**
- **Combi beams with supply air**
- **Dampers**
- **Regulation equipment**



Heat radiation seeks out the coldest areas and results in warm floors.



To avoid the heating and cooling systems operating at the same time, the systems are regulated in sequence.

Insinööritoimisto

WATERPUMPS WP Oy

CUTTING THE COSTS OF SMALL-SCALE HYDROPOWER PLANTS

New technology developed and patented by the Finnish Engineering company Waterpumps WP Oy is capable of increasing the efficiency of small-scale hydro plants to match that of larger stations. WP's system of modular construction reduces building costs by a third, while comprehensive automation offers improved reliability and lower personal costs.

WP's innovative configuration involves linking the turbine runner and watertight generator to the same shaft inside the penstock. In traditional hydro-electric power plants, generators are sited away from the penstock, making transmission machinery essential, which in turn requires extra space, increases costs and reduces efficiency. WP's solution eliminates the need for transmission equipment, allows the efficiency of hydro plants as small as 300-500 kW to be raised to levels typical of much larger hydro-electric units. The machinery can be installed directly in the waterways.

About ten years ago WP developed a nitrogen pressure system to prevent leakage. The bearing house and the generator are higher than the water pressure on the outside. In the event of a leak, the gas will start to flow out and the turbine is stopped automatically.

The entire machine module can be placed completely under ground, leaving the surrounding environment unaffected, as aspect obviously appreciated by both enviromentalists and local people. Only a small building for switching equipment and automation is erected above ground.

Waterpumps WP Oy produces two types of hydropower units, tube turbines and compact turbines. The turbines are submersible propeller turbines, in which the parts in direct contact with water are made of stainless steel. Normally, the turbines require no adjustment of vanes or runners. Several, usually three, turbines of different sizes are installed for the discharge control of the power plant. By varying the turbines, the power plant can operate at seven different discharges. The combination of running turbines are chosen according to the water level, by a logically controlled switch gear.

The operation of a power plant by constant flow turbines is more cost effective than the traditional operation with adjustable turbines, because the turbines operate constantly at optimum efficiency and produce maximum amount of energy. By using several turbines the reliability of the plant is also enhanced. Each turbine has a separate shutting device and hydraulic unit, and a partly separate electrical control.

Karhusuontie 39, FIN-00780 Helsinki, Tel. +358-9-355 907, 09-355 498, 09-355 935,

Telefax +358-9-345 4002

Waterpumps ´s latest development is a multi-generator design, in which several small generators are arranged around a single turbine axle in a watertight module. Two 1MW units of the multi-generator type were commissioned by Nurmeksen Sähkö Oy in north-east Finland, four years ago. This type of configuration incorporates four generators driven by shaft gears and grouped directly around the turbine axle. According to Matti Pirttiniemi, Waterpumps´s General Manager, the same output can be than from one large one. This solution enables the generators to be switched in one by one, allowing the plant to be brought on load gradually.

Reducing costs by a third

On the domestic market WP designs and supplies power plant packages on turnkey basis. The deliveries include permit procedures, dam and building construction, turbines, generators and electrical systems. WP has until now engineered some power plants in Finland, with outputs ranging from 100 to2,000 kW. In addition to Nurmeksen Sähkö Oy, customers have included Enso-Gutzeit Oy, Etelä-Suomen Voima Oy and Pohjolan Voima Oy. Waterpumps WP Oy ´s unmanned, fully automated units are assembled from standard modules with a high degree of factory prefabrication. This, together with the use of cost-effective components, brings the cost of building a 100-500 kW unit down to under two-thirds that of conventionally built equivalents.

With the aid of modem technology, it is often economical to replace and fully automate even small turbine units. Savings can replace and fully automate even small turbine units. Savings can also be made in fuel transport costs, an important factor as most untapped hydro-electric potential is in remote and sparsely-populated areas. According to Mr. Pirttiniemi one 500 kW hydro plant can generate energy equivalent to around 1 million litres of oil a year, which in transport terms means 50 road tankers of oil per year.

Easy to install in existing structures

Turbine configurations designed and built by Waterpumps WP Oy also makes it possible to generate power from old or existing hydraulic structures designed for other purposes. At the power plant built for Enso-Gutzeit at Ediskoski, the turbine package was installed in a tower sunk behind an old dam. The new structures are hardly noticeable.

At the moment WP is building Kamari a 200 kW power station in Estonia and a 360 kW power station for Manora Kraft Ab, at Kuuskoski. The three turbines will be installed next to an old mill from the 1800´s, preserving the historical building intact. The power plant´s impact on the idyllic landscape is minimal. Other recent Wp´s projects include a 510 kW fully-automatic power plant for Vakkolan Voima Oy, a 1,3 MW for Liunan Voima Oy and a 245 kW power station at Ramsele in Sweden. Jylhän Sähköosuuskunta 550 kW tube turbine power plant was commissioned Oct. 1996.

A NEW GENERATION OF WATER TURBINES

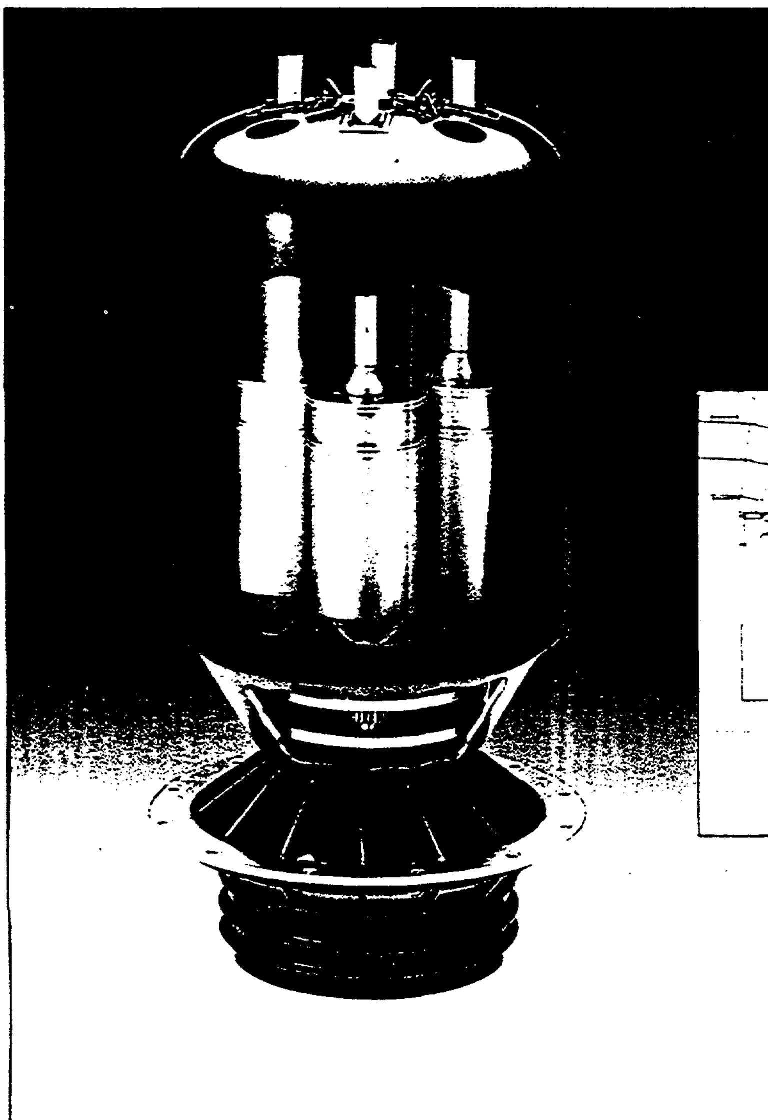
EQUALLY WELL SUITED FOR NEW POWER PLANTS AND FOR REBUILDS

We produce two types of water-power units, i.e. tube turbines and compact turbines. In both configurations, the turbine is integrated with the generator into a watertight module for direct installation in the waterway. The turbines are propeller turbines and the generators are asynchronous alternators. Very little space is required for the installation. The entire machine module can be placed under ground and only a small building for switching equipment and automation is erected above ground.

Construction
- the waterways of the turbines are of stainless steel
- fixed runner and guide vanes
- in the range of 20 to 500 kW the turbine and the generator are linked to the same axle for direct drawing
- larger units, for 500 to 5 000 kW, are equipped with multi-generator turbines, i.e. several gear-driven generators are arranged around the turbine.

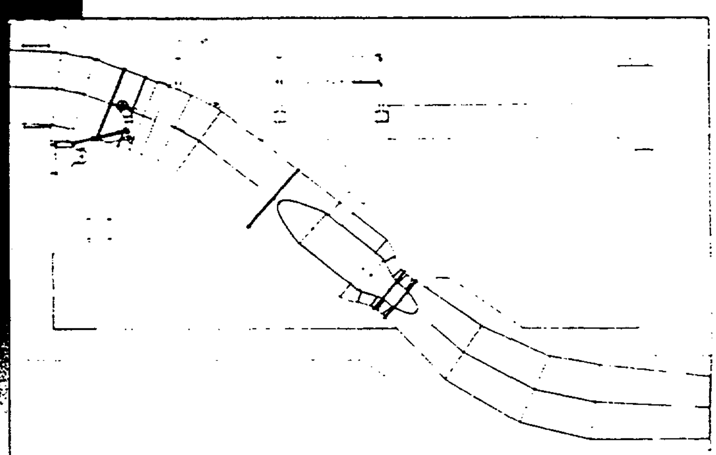
Automation and control
The turbine is controlled and monitored automatically by a logic. Oil and generator chambers are pressurized by protective gas to eliminate water leaks into the turbine.

Advantages
- the unit blends into the surroundings
- fast installation
- maximum cost efficiency at all times
- long service intervals
- fully automated



Services by Waterpumps Ltd:

- pre-engineering
- permits
- planning and design
- construction
- turbines
- electrification
- automation
- installation
- sluices



The turbine and the generator are installed in the penstock.

The turbine and the generator are linked to the same axle. Several generators are used with turbines for over 500 kW.

PPU SUBMERSIBLE PROPELLER PUMPS

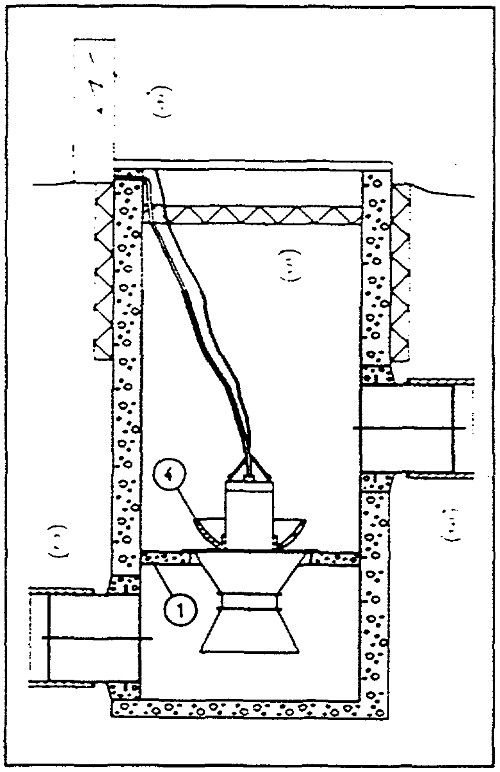
ne PPU pymps are axial flow pumps for submerged installation, pecially designed for high rates of water 0 to 20,000 l/s) at delivery heads below 10 m.

eneral and expedient applications:
agricultural drainage, irrigation and flood control pumping
water supply for fish breeding
ndustrial and municipal raw water intake
regeneration by change of water and/or by aeration
control of water level and discharge in artificial ponds, channels and waterfalls

dvantages of submerged installation:
total elimination of ice problems
simple pumping solutions without stationary structures above ground

e pumps are normally equipped th a quick coupling system ich permits connection and sconnection without any tools. equired, a back flow system can installed in the pump or in the terway of the pumping plant. e position of the pump can be osen freely.

e manufacturer can supply ndard plans for pumping plants d installation.



Pump
Inlet
Outlet
Back flow gate (rubber)
Cover
Switching unit

COMPREHENSIVE POWER PLANT CONTRACTING

WATERPUMPS LTD is an engineering agency specialized in hydrotechnics. The first product of the compan, which was established in 1972, was a hydraulically operated submersible propeller pump. Hydraulical operated pumps were supplanted by electrically operated submersible pump which Waterpumps Ltd manufactures since 1976. Prompted by the good resul with the submersible pump the manufacture of turbines began in 1982. Waterpumps Ltd has engineered practical all the small-scale hydroelectric power plants built in Finland over the past few years.

WATERPUMPS LTD
Karhusuontie 39
00780 Helsinki, Finland
Telephone +358-0- 355 907
Telefax +358-0- 345 4002

NESTE
Advanced Power Systems

NAPS - NESTE ADVANCED POWER SYSTEMS

* NAPS IS A HIGH TECHNOLOGY BUSINESS DEVELOPMENT UNIT OF NESTE CORPORATION

* NAPS WAS ESTABLISHED IN 1986 AS A RESULT OF AN INTRODUCTORY CORPORATE R&D PROGRAMME ON NEW ENERGY TECHNOLOGIES

* NAPS DEVELOPS, MANUFACTURES AND MARKETS INTERNATIONALLY ADVANCED RENEWABLE ENERGY SYSTEMS

* NAPS SPECIALIZES IN
  - SOLAR ELECTRICITY
  - SOLAR HEAT AND COOLING
  - WIND POWER,
    and related
  - ENERGY STORAGE AND CONTROL TECHNOLOGIES

* NAPS HAS DELIVERED SYSTEMS TO OVER 40 COUNTRIES WORLDWIDE FOR
  - CONSUMERS
  - RURAL ENERGY SUPPLY APPLICATIONS
  - INDUSTRIAL APPLICATIONS

* NAPS HAS 100 EMPLOYEES AND ITS TURNOVER WAS $16 MILLION IN 1996

* NAPS' MARKET SHARE:
  - LEADING COMPANY IN SCANDINAVIA
  - 10 % MARKET SHARE IN EUROPE
  - 2-3 % MARKET SHARE WORLDWIDE

NESTE
Advanced Power Systems

Jaana Sirkiä 02-04-97 1/1

NESTE ADVANCED POWER SYSTEMS (NAPS)

Neste Advanced Power Systems (NAPS) was established in 1986 and it belongs toNeste Group's Energy Division. NAPS develops, manufactures and markets solar (solar electricity and solar heat) and wind energy systems. NAPS has offices in Finland, Sweden, Norway, France, Kenya and UK.

Product range comprises of:

Consumer Applications:

* Applications for water pumping, lighting, TV,radio,phone and water heating.
* Electricity for boats and caravans
* Solar Heating and cooling
* Alarm systems

Rural Energy Supply Products and Projects

* Lighting
* Telecommunication
* Irrigation
* Cooling (health care and nutrition)

Industrial Products and Projects

* Telecommunication
* Cathodic protection
* Village powering
* Navigation
* Facades and UPS-systems

isovolta
Österreichische Isolierstoffwerke AG
A-2355 Wiener Neudorf

ISOVOLTA - Partner of the Photovoltaic Industry

Materials and Machinery for PV-Module Production

For decades ISOVOLTA has specialized on the production of composite structural materials, which are used in the construction, furniture, electrical and aircraft industries.

As a result ICOSOLAR was developed - a laminate, which the photovoltaic industry has used on an international level over years.

ISOVOLTA offers new top-quality solutions based on a customerorientated development and an integrated quality assurance system.

The ISOVOLTA Plants and Equipment Section is engineering different types of Vacuum Laminators according to customers specification.
Recently new efficent systems have been developed for the continous production of PV-modules.

Together with its partners ISOVOLTA supplies all machinery, equipment and know how for PV-module production.

Photovoltaic- generating electric current by converting solar energy

The Greenhouse effect and environmental pollution compel us to work out intelligent proplem solutions. Photovoltaic - energy gained from light - is a renewable source for
high-grade electric energy, thus making vital contributions to the finding of solutions.

There are various means of application ranging from low-energy equipment for emergency call boxes or mobile homes, integrated roof and facade installations to large solar power plants.

isovolta
A-8402 Werndorf

ICOSOLAR for Photovoltaic Modules

ICOSOLAR is a laminated composite structural material consisting of several different layers. ICOSOLAR is used for electrical insulation and encapsulation of solar cells and to protect them from weather and humidity.

The product line includes variants with a total vapor barrier effect. Special colours are offered to meet individual design-needs. ICOSOLAR is either opaque or transparent.

ICOSOLAR is also available completely integrated with EVA sealing film and glass fiber mat, thus considerably simplifying the production of PV-modules.

ISOVOLTA offers the chance for laminating trials in its laboratories.

Please contact:

Sonnenkraft Vertriebs GmbH
Im Mühltal
A-4655 Vorchdorf

Christian Mundigler
project manager

Tel.: 0043 7614 6006
Fax.: 0043 7614 6006 17

SONNEN KRAFT
Solar-besonnen ins 3. Jahrtausend

ABOUT SONNENKRAFT

Sonnenkraft, the number one on the Austrian solar market, is an international marketing organisation with establishments in Austria, Germany and Switzerland. In 1996 the market share in Austria was over 25 %. That is equivalent to an installed area of solar collectors of 60 000 m^2. Sonnenkraft stands at the beginning of the ambitious intention to become the number one in Europe. It distributes its products via contractors and specialists like plumbers. Until now Sonnenkraft convinced 1000 contractors to become one of its partners. Professional marketing and technical support helps them to sell its products to the customers by keeping their expense at a minimum.

OUR PHILOSOPHY

Making the enormous natural forces useful which are the sun, the rain and the plants is the main effort of our research, development and production: Within of this energy triangle in which the sun is the centre we place all our activities. The use of modern high technology is as normal as saving natural resources. By the careful opening and the optimal use of natural energy resources we fulfill our assignment to ensure an independent energy future for our children. The aim for the next century is to include the use of sun power in every bodies daily life as a normal standard. For Sonnenkraft high quality is as important as the permanent development of new products to open new markets with new applications.

OUR PRODUCTS

Depending on which energy resource you want to use we offer:

Sunpower — **Solar plants** in every size either for households or whole villages to supply people with hot water and central heating. For each application we have the right collector: The accomplished collektor SK500, the roof integrated collector SKIDK or the large plane modul collector SKIMK. The special quality is shown in high water temperature, little loss of heat and very high life time of 30 years.

Rainpower	**Rain using plants** to make the rain useful not only in the garden but even in the whole house for washing the clothes, flushing the toilets and cleaning. Using the rain can save 47% of the 150 litres of valuable drinking water every person needs per day.
Plantpower	**Compello central stove-heatings** to heat with CO2-neutral wood pellets enjoying the most comfortable radiation heat in the living room. Even the warm water and the central heating in the rest of the house is managed by the Compello fully automatically.

AWARDS

1995	Research and Innovation Award of Carinthia for the development of the accomplished solar collector SK 500
	Best young enterprise of Austria
	Environment Oscar of Carinthia for the invention of a new packing of the integrated collector SKIDK avoiding any packing material.
1996	Innovation Award of the Energiespar Messe Wels (yearly energy saving fair in Upper Austria) and ORF (Austrian radio and television organisation) for the development of the Compello central stove-heating.

Administration and Marketing	*Warehouse and technical Office*	*Sale, Warehouse, techn. Office*	*Sale, Warehouse, techn. Office*
Sonnenkraft Vertriebs GmbH	**Sonnenkraft Vertriebs GmbH**	**Sonnenkraft Vertriebs GmbH**	**Sonnenkraft Tech AG**
Solar & Ökozentrum	Im Mühltal	Reitfeld 6	Schlattstraße 7
A-9321 Kappel/Krappfeld	A-4655 Vorchdorf	D-93086 Wörth a. d. Donau	CH-9464 Rüthi
Tel.: 0043 4262 4633	Tel.: 0043 7614 6006	Tel.: 0049 9482 90103	Tel.: 0041 71 766 2566
Fax.: 0043 4262 4633 17	Fax.: 0043 7614 6006 17	Fax.: 0049 9482 9105	Fax.: 0041 71 766 2567

SONNEN KRAFT

Solar-besonnen ins 3. Jahrtausend

HOTAB ELDNINGSTEKNIK

HOTAB was founded 1979.

HOTAB project, consult, manufacture, sell, assemble, put in operation, hire out and service combustion equipments in Sweden and the rest of the world.

Most of our customers are located in Sweden, the Baltic states, Russia, Poland and Denmark.

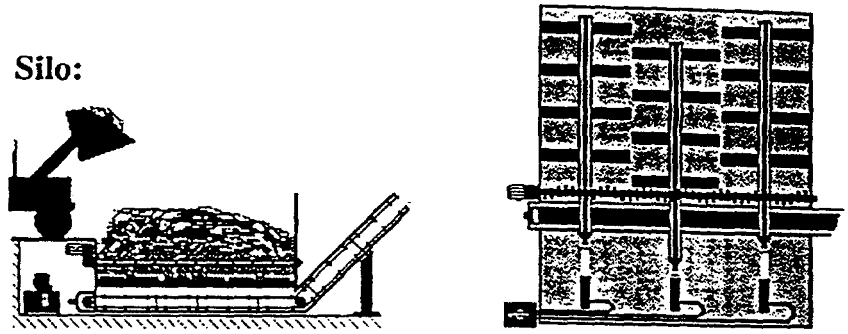
The field of activity of the HOTAB Group today embody manufacturing in our own mechanical workshop, a service company, a construction company, a development company and an electric company.

The HOTAB Group has at the moment 30 employes all together and the different companies are located in Kristianstad, Tollarp, Jönköping, Riga and the head office in Halmstad.
Our main purposes are to have a high quality and a high standard on all our products and our work. We always try to be a personal company.

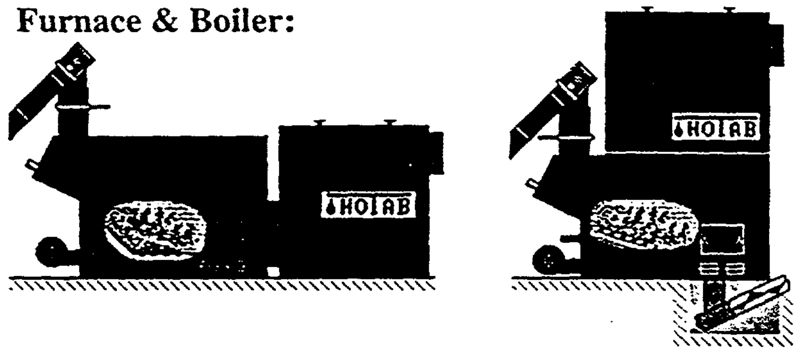
<u>What does HOTAB have that makes us competetive?</u>

We have offices and service personel on different locations in order to be close to our customers.
We can connect our new and modern furnaces to old boilers.
We always plan for the very best solution of all firing problems.
We have very modern and carefully tested firingsystems.
We have our own operationsystem from Siemens which is the best on the market.
We have education for the boilerstaff according to the current regulations in our education center.
We can also offer education on the place for the equipment.

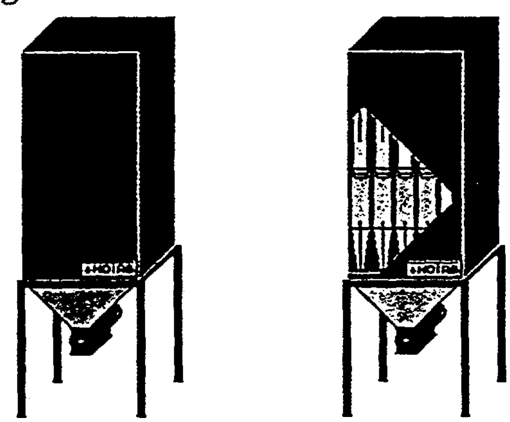
Silo:



Furnace & Boiler:

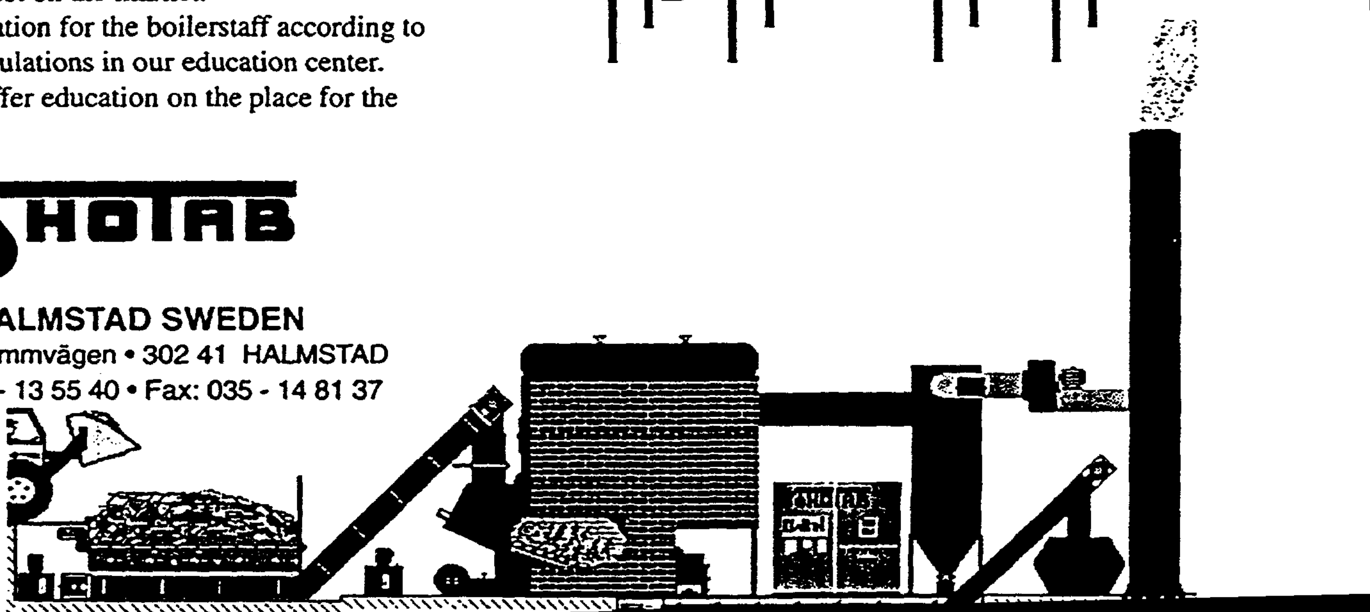


Smokegascleaner:



HOTAB

HALMSTAD SWEDEN
Gamledammvägen • 302 41 HALMSTAD
Tel: 035 - 13 55 40 • Fax: 035 - 14 81 37



HOTAB
ELDNINGSTEKNIK

EXTRACT FROM HOTABs INTERNATIONAL REFERENCE LIST

NAME	CAPACITY	FUEL/ MOISTURE
VIISNURK A/S PÄRNU, ESTONIA	2 X 6 000 kW	Wood chips 50%
ZIELONA GORA, POLAN	2 700 kW	Saw dust, wood chips 45%
VERMO VÖRÖ, ESTONIA	2 000 kW	Wood chips 50%
KLINISKA, POLAND	1 100 kW	Wood chips 50%
BALDONE, LATVIA	2 000 kW	Wood chips 25-50%
BALVI, LATVIA	3 000 kW	Wood chips 35-55%
JOGEVA SOOJUS LTD, ESTONIA	7 000 kW	Wood chips 35-55%
VIISNURK, ESTONIA	7 500 kW	Wood chips, bark 35-55%
SLAMPE, LATVIA	3 500 kW	Wood chips, bark 35-55%
KAZLA RUDOS, LITHUANIA	3 500 kW	Bark, wood chips 35-55%
UGALES PAGASTA, LATVIA		
OBERNIKI, POLAND	2 000 kW	30-50%
SVENTUPE, LITHUANIA		
JURMALA, LATVIA	7 000 kW	Wood chips 55%
BAISOGALA, LITHUANIA	4 000 kW	Wood chips, bark, saw dust 35-55%
BELOOSTROVSKAYA, RUSSIA	6 x 700 kW	Wood chips 55%
VARENA, LITHUANIA	8 000 kW	Wood chips 55%
BYDGOSKIE, POLAND		

TiNOX

Gesellschaft für Energieforschung und Entwicklung mbH

What is TiNOX ?

TiNOX is the all round positive answer to the question regarding the future of solar plants. TiNOX stands for the new generation of high-performance absorbers for thermal solar plants. The absorber is the central part of each solar collector; it catches the sun's rays and exchanges them into usuble energy. The output of the absorbers is decisive for the efficiency of the whole solar plant. The new TiNOX absorbers enable collectors to achieve an output that was considered unattainable up to now.

OUTPUT

A solar collector equipped with TiNOX catches 95 % of the solar energy and only loses 5 % of this energy due to radiation. The result: noticeably higher output during the less sunny winter period and greater comfort during summer.

VIABILITY

Thanks to this new level of output the slight price difference of a solar plant with TiNOX is soon amortised.

QUALITY

Even after 25 years TiNOX still has a rate of performance of 99.6 % of the original rate. This is certified by long-term tests at the Swedish National Testing and Research Institute, regarding the stability against the influences of ageing, temperature and dampness.

RESPONSIBILITY

TiNOX absorbers set new ecological standards. The products do not release any noxious emissions at all and use 90 % less energy than conventional galvanised processes. The coating material titanium-nitrate-oxide (TiNOX) is non-toxic and can be re-cycled, as can the copper strip upon which the coating is pressed on to.

TINOX IS IMMEDIATELY RECOGNISABLE

The semi-gloss (matt shining) blue is unique and unmistakable.

TINOX GmbH Schwere-Reiter-Str. 35/2b, D-80797 München Tel.: 0049 89 / 300072-0, Fax.: 0049 89 / 300072-72

SolarNor AS

Solar collector in plastics for building integration

The SolarNor solar heating system has recently been laughed i Norway. The system represents a second generation solution of the basic principles applied by the company characterized by roof- or facade integrated solar collectors operating at a pressure lower than the atmospheric pressure and automatic drain back of the circulating water as soon as the energy harvesting stops.

The solar collector is composed of two twin-wall sheets in engineering plastic materials, LEXAN® Thermoclear as transparent cover, and NORYL® PX507 as the basic material of the absorber. Both sheets are manufactured by General Electric Plastics.

Besides the use of the modified PPO material NORYL®, which has excellent hydrolytic properties for the application in the absorber, the novelty of the present concept is the heat removal principle applied.

Pure water trickles through a channel structure in the absorber plate and deposits the absorbed heat. The channels are filled with ceramic particles, which provide good thermal contact between the water and the energy absorbing surface of the absorber and establish a hydrodynamic pressure below the atmospheric pressure during operation. This patented design combines efficient energy harvesting and limited stress on the material.

The solar collector is manufactured in terms of building elements with a standard width of 60 cm substituting conventional roof or facade materials. The water supply is placed below the row of collector modules, where each module is connected by means of of single tube-in-tube joints. When the circulation pump stops all water will trickle out of the collector within a few minutes. Hence the system is effectively protected against freezing or boiling damages.

The principles of integration, the low amount of materials required due to the limited mechanical stress, and the highly industrialized manufacturing of all the collector elements, offers the opportunity of low costs solar systems. The price of the collector modules is presently 600 NOK/ m^2.

Most of the installed systems during the fall 1996 are combined domestic hot water and space heating systems for private one-family houses. The systems include, in addition to the new collector, low temperature-floor heating and heat storage in terms of water tanks from 1000 to 3000 liters. Presently, some applications in large scale solar systems are under preparation.

The plastic collector has received considerable international attention.

SolarNor AS
Erling Skjalgssons gate 19A
N - 0267 OSLO
Norway

Tlf.: +47 22 12 90 80
FAX: +47 22 12 90 89

BIOGAS AS - YOUR PARTNER FOR THE UTILIZATION OF GAS FROM LANDFILLS

Biogas AS has the level of "know-how" to give you the requested service from the early beginning to the end of your project.

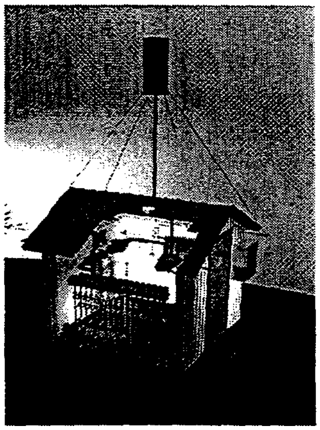
BIOGAS AS - TECHNICAL COUNSELLOR
Valuable experience through 10-15 projects yearly for the municipalities on:

* Theoretical pre-projects
* ES-testing
* Test-pumping of gas with 2-3 wells in full scale

BIOGAS AS - BUILDING TURN KEY PLANTS - SEVERAL DIFFERENT MODELS

Model "Compact"
A simple pre-manufactured small process-plant with a gas burner. The compact plant is suitable for landfills containing up to about 100.000 ton of waste.

Model "Standard"
Process plant operated by hand, but all alarms are automatically written out. Suitable for landfills that have workers on the landfill for the control of the plant.



Model "Auto-Medium"
This plant is PLS operated and equipped with a PC.
All the analysis are taken automatically 24 times a day.
Historical dates and trendcurves is worked out. The flow scheme on the screen can be transported to an extern central, together with alarms etc.

Model "Automatic"
Built as the Auto-Medium plant, but the well-valves can be operated automatically inside the plant or from a central.
A highly efficient plant with a top quality gas that gives you the optimal quantities.

BIOGAS AS - ENERGY PRODUCTION
Quality gas can be burned directly for the use of the heat in industrial production, or the gas energy can be generated to El-power.

BIOGAS AS IS ALWAYS TO YOUR DISPOSAL FOR MORE INFORMATION

Best regards,

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