ERIGEN Power Supply System in the Track Radio Network of the Swedish State Railways

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One of the major problems encountered by the Swedish State Railways (SJ) when extending its track radio network in sparsely populated areas is how to power the base radio stations. Ericsson's primary power system ERIGEN is an alternative which gives great freedom in the choice of site for a base radio station. An ERIGEN system has been in operation for some years at one of the SJ base radio stations along the inland main line. The solar and wind system is designed to power remote telecommunications plants situated far from the electricity mains.
The authors describe the design of the system, its parts and also the operational results obtained during the 2 1/2 years of service.

power supplies to apparatus
railways
radio networks

Since the beginning of the 1970s SJ, the Swedish State Railways, has made large annual investments in order to provide all its tracks with modern radio communications. The radio network is used by the engine drivers, who now always work alone in the locomotives, and by the maintenance staff during work on the tracks. It is an important safety factor, particularly in sparsely populated areas, that reliable radio communications are available everywhere, for example in the case of incidents or accidents when assistance must be summoned quickly.

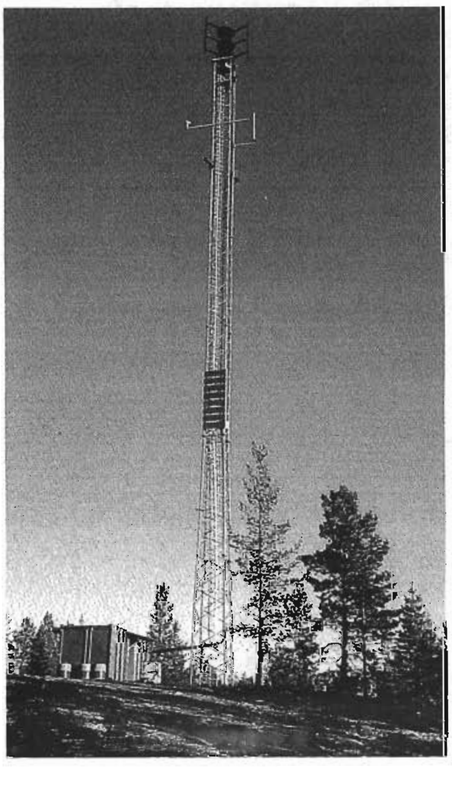

Fig. 1
The base radio station at Jämnvallen

The Sundsvall railway region, fig. 2, handles the expansion in a section right across northern Sweden and now has 104 base radio stations in its fixed track radio network. In 1980 the expansion had reached the route Brunflo–Sveg, a 170 km long part of the main inland railway in northern Sweden. The route was measured for radio and the project planning started. This showed that the cost of providing the remote base station at Jämnvallen, fig. 1, with electricity would be very high. A postponement decision was therefore made: that of shelving the project and accepting a gap in the radio coverage of approximately 10 km. Since the system is designed as a chain of radio links with many repeater stations this made it very difficult to obtain good-quality radio circuits to the terminal station.

SJ was not satisfied with this state of affairs and started an investigation in order to find an economically and technically reosonable solution. All-diesel operation, small water power plants and alternative power sources such as sun and wind power plants were studied. SJ found that ERICSSON SUNWIND[1] was a possible solution to this problem.

A trial plant with Ericsson's wind generator and solar panels was discussed during 1982/83. Another topic for detailed discussions was the type of building to be used. It would be difficult to heat the building during the winter since the energy obtained from the solar and wind power plants would be limited. The plants would only be dimensioned for the requirements of the radio equipment.

Ericsson proposed a buried tank that could take up earth-heat during the winter. The plant would then not require any energy for heating. However, SJ considered this alternative too expensive and the trade unions advised against it in view of the resultant impractical working conditions for service and maintenance.

SJ chose to install the station in a 20' insulated standard container. SJ wanted to try this as a new type of radio building which has the advantage of allowing the equipment to be installed and tested at the factory. This means lower costs as

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compared with the on-site work otherwise necessary.

The solar and wind power plant was supplemented by a diesel generator which was to serve as a standby, primarily because of the expected long periods of calm and of little sunshine. The heat from the cooling water of the diesel generator was to be stored in an accumulator tank, which was to form part of a hot-water system. Thus the role of the diesel generator in the power supply system was extended to being the heating plant for the station. Using the heat of the cooling water improves the fuel economy. The running time of a diesel generator used as the standby in a solar and wind power plant is normally estimated to be approximately 200 hours/year, but with the additional heating function this value is expected to be doubled.

No energy for heating the container was to be drawn from the wind generator or solar panels. The justification for this decision was that in the case of a fault in the diesel generator in cold weather the radio transmitter would discharge the station battery unnecessarily quickly. This would increase the risk of disturbances of the radio traffic. After an initial test period the possibility of using wind and solar energy to heat the container would be reconsidered.

The plant has been built up in stages. During the initial stage it consisted of just the diesel generator. Approximately one and a half year later it was supplemented with a wind turbine and solar panels.

Power supply system

The Jämnvallen power plant is a complete ERIGEN solar, wind and diesel power system. It powers the radio station and a data collection and remote control system. The power requirement is 60 W for the radio station and 40 W for the data collection and remote control. The power plant has three independent power sources which are connected in parallel to the station battery, fig. 3.

Solar panels

The solar power in the system is provided by eight solar panels with a total peak output of 400 W. The panels are divided into two sections, each with four panels connected in series. They are mounted vertically on the lower part of a 36 m high mast, fig. 1. The panels are

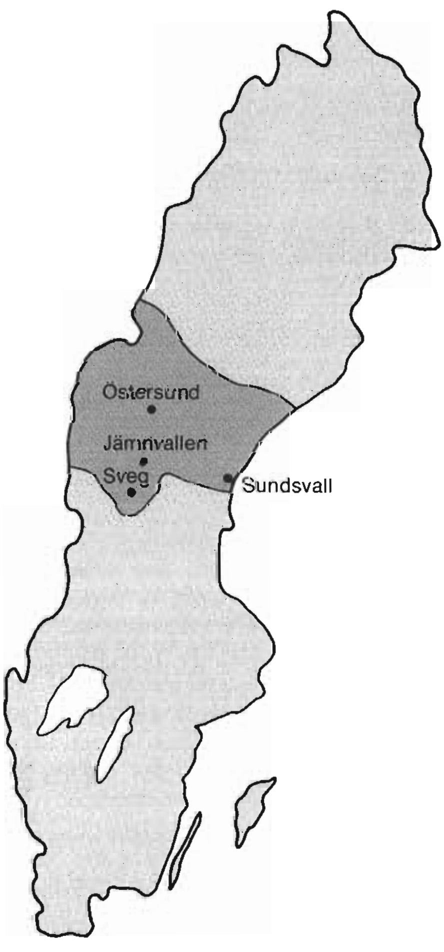


Fig. 2
Sundsvall railway region

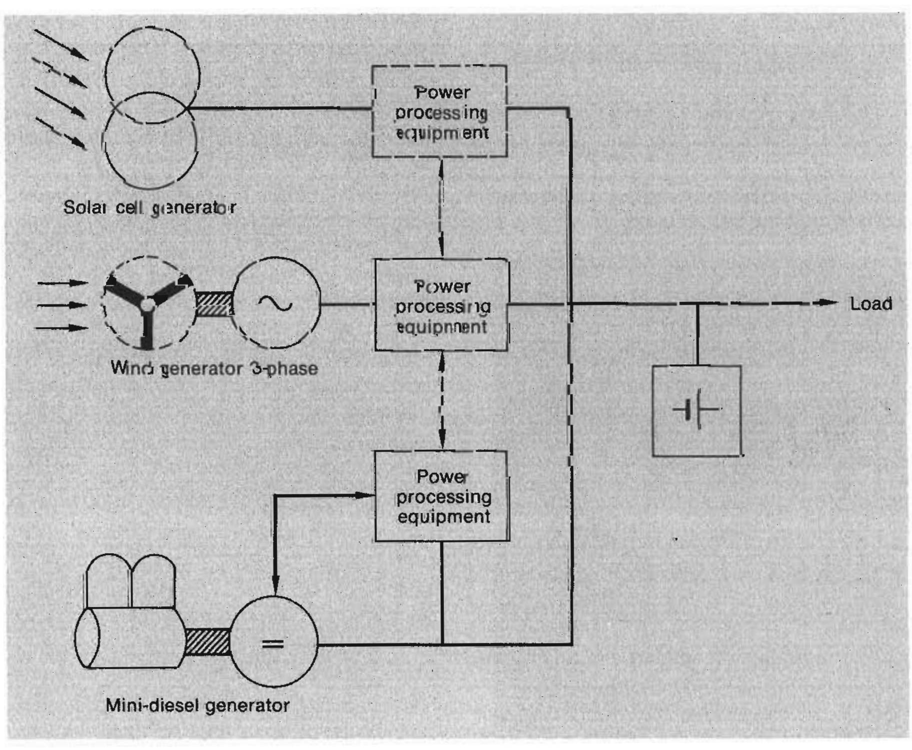


Fig. 3
Block diagram of the ERIGEN primary power system

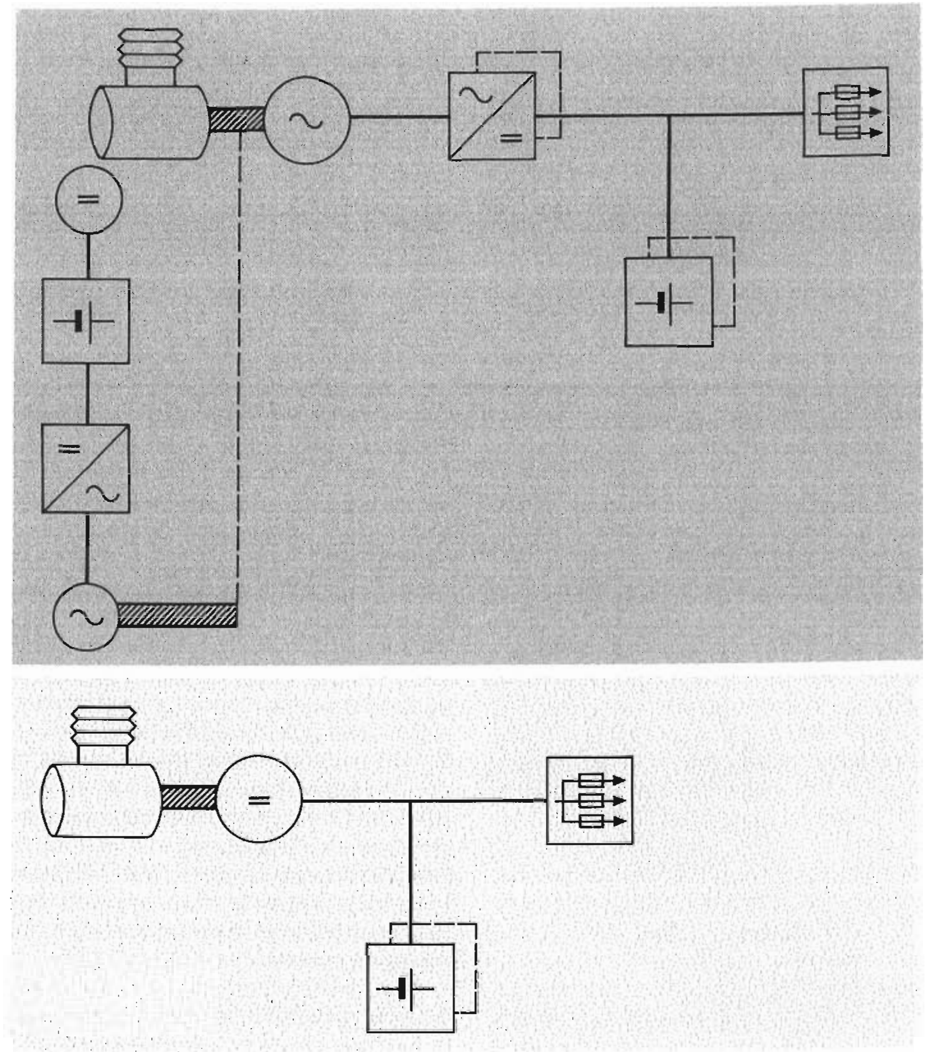
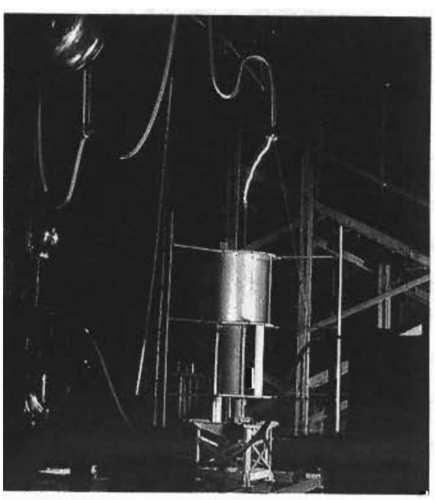


Fig. 5
Block diagram showing the difference between a conventional diesel generator (blue) and the ERIGEN mini-diesel generator (yellow)

Fig. 4
The ERIGEN wind turbine in lightning tests at a high-tension laboratory



separated by slits in order to reduce the surface exposed to the wind. The solar panels are connected directly to the battery without any control or regulating unit.

Wind generator
ERIGEN contains a SAAB-Ericsson VA3 wind generator with a vertical axis and 950 W peak power. It has a directly connected slowly rotating a.c. generator whose field is provided by permanent magnets. The alternator has very high efficiency, particularly when the wind speed and hence the number of revolutions per minute are low. The wind turbine is equipped with an independent regulator which limits the r.p.m. to a maximum of 300 at high wind speeds. The power regulator is computer-controlled so that the power output from the wind power plant is matched to the available wind power.[2] The battery charging voltage is also regulated to a highest permissible value.

The wind generator, which is mounted at the top of the radio mast, has built-in, patented protection against damage by lightning, fig. 4. Lightning damage usually falls into two categories. One is damage to semiconductors and the generator winding by overvoltages, the other is damage to the ball bearings by the discharge current. The latter type manifests itself as welding damage to the surfaces of the balls and the ball race. The ball bearings have therefore been isolated so that no current can flow through them. The electrical part of the lightning protection has been constructed of traditional gas discharge tubes and metal oxide varistors.

Mini-diesel generator
The mini-diesel generator in the system has a peak output of 1.5 kW 48 V d.c. The unit consists of a twin-cylinder, water-cooled light-metal motor which operates at 2300 r.p.m. and a d.c. generator which charges the radio station battery directly, without any intermediate rectifier. Unlike conventional diesel generators this unit has no separate start-up battery but uses the station's main battery. This has been made possible because the generator is also used as the starting motor, fig. 5.

In the latest version of the mini-diesel unit the motor has been mounted on top of the generator, fig. 6. Hence the unit is very compact and only requires a floor area of approximately 0.6x0.5 m. The motor and generator in the mini-diesel unit weigh approximately 50 kg each. The small dimensions and low weight of the equipment are advantageous. It is

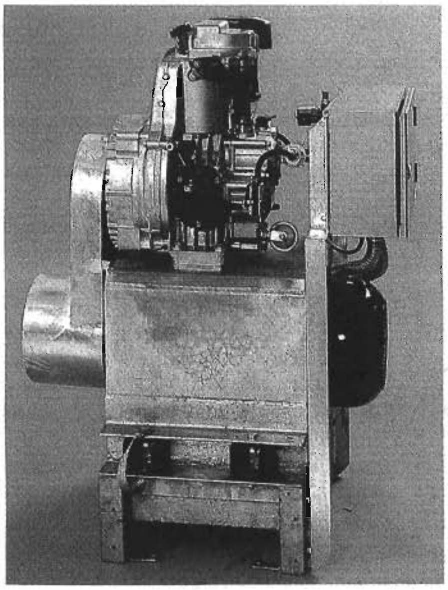


Fig. 6
The latest version of the ERIGEN mini-diesel generator. Air-cooled variant

essential for the installation and maintenance of remote radio stations that the equipment can be carried by one or two men and be transported by a helicopter or cross-country vehicle without requiring special heavy lifting gear.

Battery
The station battery has a system voltage of 48 V and a capacity of 468 Ah. It is an antimony-free lead battery, which is placed in the same room as the diesel generator. The room has no ventilation and the battery is therefore equipped with an exhaust system that takes the battery gases out of the station container, fig. 7.

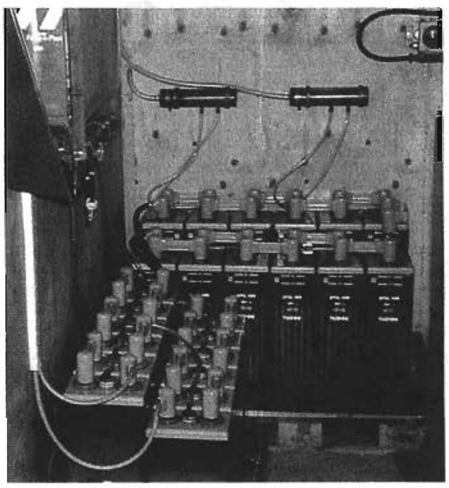


Fig. 7
Battery gases are removed by a system of tubing. The battery can therefore be installed in a closed, unventilated room

Container

The radio station is installed in an insulated 20-foot standard container, which is divided into two rooms. One room contains the battery and the diesel unit with its fuel tank and heat accumulator tank, and the other the control electronics for the power supply system and the radio equipment.

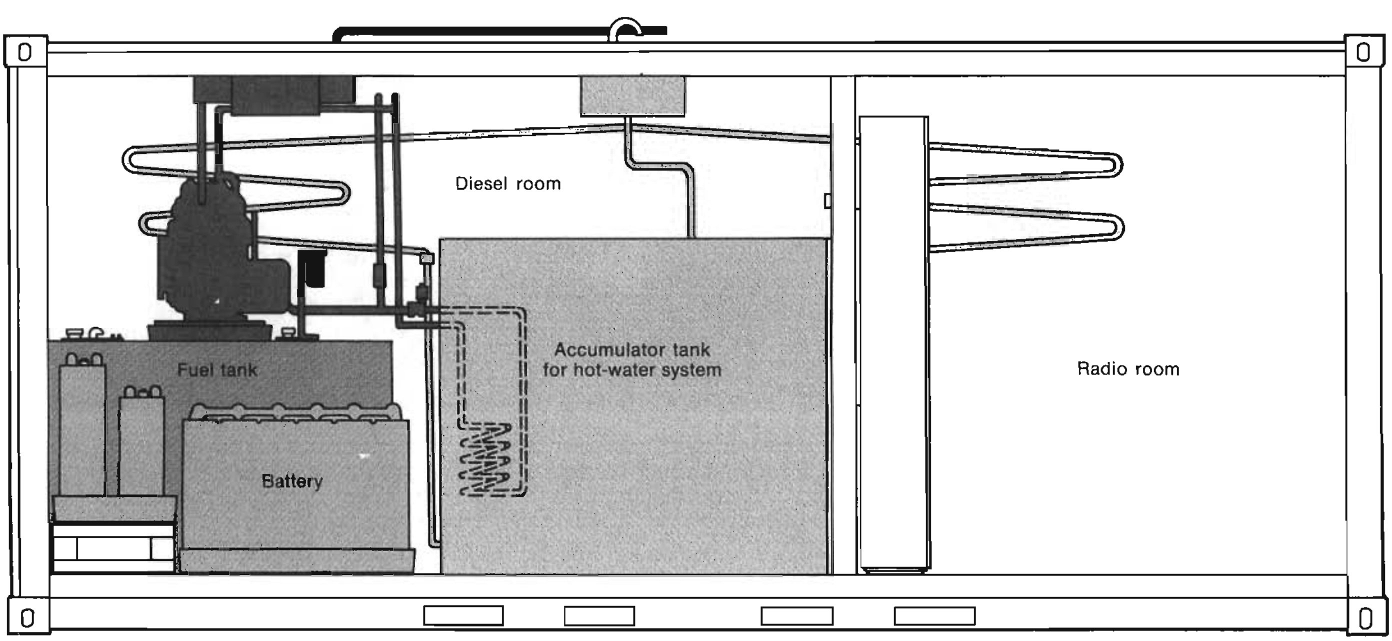
During the winter the container is heated by the cooling water from the diesel motor, which via a heat exchanger and accumulator tank supplies a hot-water system. The plant has worked in temperatures below −40° C without trouble, fig. 8.

Data logger and remote control

An ERIGEN data logger and remote control equipment has been installed for remote operation and evaluation of the system.[3] The telecommunications network is used for the data collection and control. The data logger contains a modem with automatic answering. The data logger is called once a day and requested to send a file of operational data. The file contains accumulated data for the previous 24-hour period. Alarms are transmitted immediately by the data logger, which calls up and specifies the faulty equipment.

The data assembled by the data logger can be divided into three categories:
- Meteorological and environmental data, comprising wind speed, wind direction, various temperatures and air humidity.
- Power and energy data from the different parts of the primary power equipment: the wind generator, solar panels, mini-diesel generator, battery and the load.
- Remote control data and system alarms. The remote control equipment can handle 16 different functions and receive 16 different alarms. It can also read indications, alarms and various status codes in the data stores of the wind power and mini-diesel equipment.

Fig. 8
The power supply equipment in the container housing the SJ base radio station



Operating results

The equipment was installed in June 1984. It was powered solely by the diesel generator until February 1986, when it was supplemented with solar panels, wind generator, data logger and remote control equipment.

During the period up to the installation of the wind generator and solar panels there were irregularities in the peripheral equipment of the diesel generator; its electronic supervision and fuel supply system. This experience confirms earlier experience of diesel generators: that faults usually occur in peripheral and auxiliary systems but seldom in the motor unit itself. The faults were cleared and did not affect the radio traffic to any appreciable extent. During the period the operating time of the diesel generator was approximately 1000 hours/year.

After the extension the power supply system has worked according to expectations. The operating time of the diesel generator has been reduced to approximately 400 hours/year, less than half of the previous time. This is well in accordance with calculations made during the project planning state. Lightning interfered with the operation twice during the summer of 1986. On these occasions electronic circuits were damaged but not the wind generator. As a result no energy values were recorded for July and August. During this period the system was operated manually by SJ staff. These incidents show how vulnerable this type of plant is to lightning damage and emphasize the importance of good lightning protection.

The data logger recorded the energy produced by the sun and wind and the energy consumed by the load. The diagram of fig. 9 shows the monthly production of energy, in kWh, by the wind generator, solar panels and diesel generator, and the consumption by the radio and control equipment. The energy used to heat the container was not recorded.

The mean wind speed at the wind turbine, 36 m above the hill, was recorded for each month and was:

Month	Jan.	Febr.	March	April	May	June
m/s	3.7	3.9	4.1	3.7	4.0	3.1
Month	July	Aug.	Sept.	Oct.	Nov.	Dec.
m)s	–	–	2.7	4.4	4.5	3.6

The operating time of the mini-diesel generator per month was:

Month	Jan.	Febr.	March	April	May	June
hours	82	52	20	22	1	6
Month	July	Aug.	Sept.	Oct.	Nov.	Dec.
hours	–	15	33	22	38	90

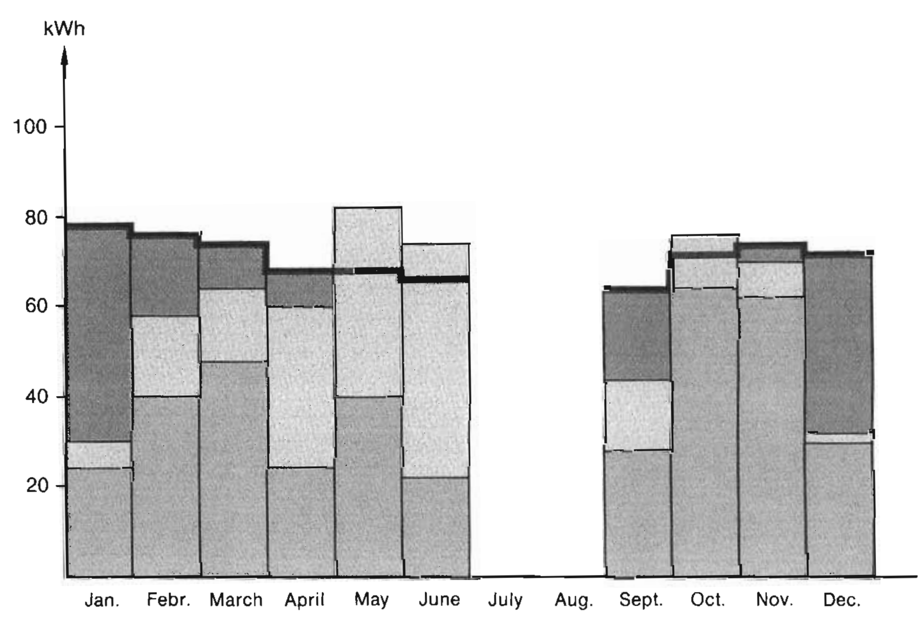


Fig. 9
Energy diagram from one year of operation of the base radio station at Jämnvallen

Load
Diesel energy
Solar energy
Wind energy

Accumulated data for the ten months of operation:

Total diesel operating time	380 hours
Total energy consumption	715 kWh
Total amount of energy produced by the sun and wind	592 kWh
Contribution by mini-diesel generator	123 kWh (17%)

The power plant has produced more energy than expected. The contribution by the solar panels corresponds to the maximum possible production since they have charged the battery without any charging regulator. The recorded contributions from the wind and diesel generators do not indicate the maximum possible contributions from these sources. Since the battery has often been fully charged the charging regulators of these two generators have for long periods kept them at a very low load or running idle.

During the second trial stage the operational reliability of the mini-diesel generator was very good. The faults that occurred during the first stage did not recur.

In view of the results described above the question whether the wind and solar power sources should contribute to the heating of the container during the winter ought to be reconsidered. Using these sources would reduce the diesel operating time even further.

Summary

The power supply system has been in operation for two and a half years and has worked very well.

The doubts regarding the feasibility of a wind power plant that were expressed during the project planning have proved to be unfounded. The wind generator and solar panels have provided more energy than the radio and supervision equipment required.

If this equipment had been available earlier SJ could have saved a considerable amount of investment capital in the siting of its base radio stations. The supply of power is one of the most important and difficult parameters for the choice of base station sites in hilly and uninhabited areas.

The Swedish State Reailways has reduced its installation costs at Jämnvallen by more than half thanks to this alternative power supply. As regards operating costs it is not possible to make any evaluation and comparison with conventional technology until after another couple of years of operation.

References

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