CADDET renewable energy
IEA
OECD

Low-head 11 MW Hydro Plant in the Netherlands

Summary

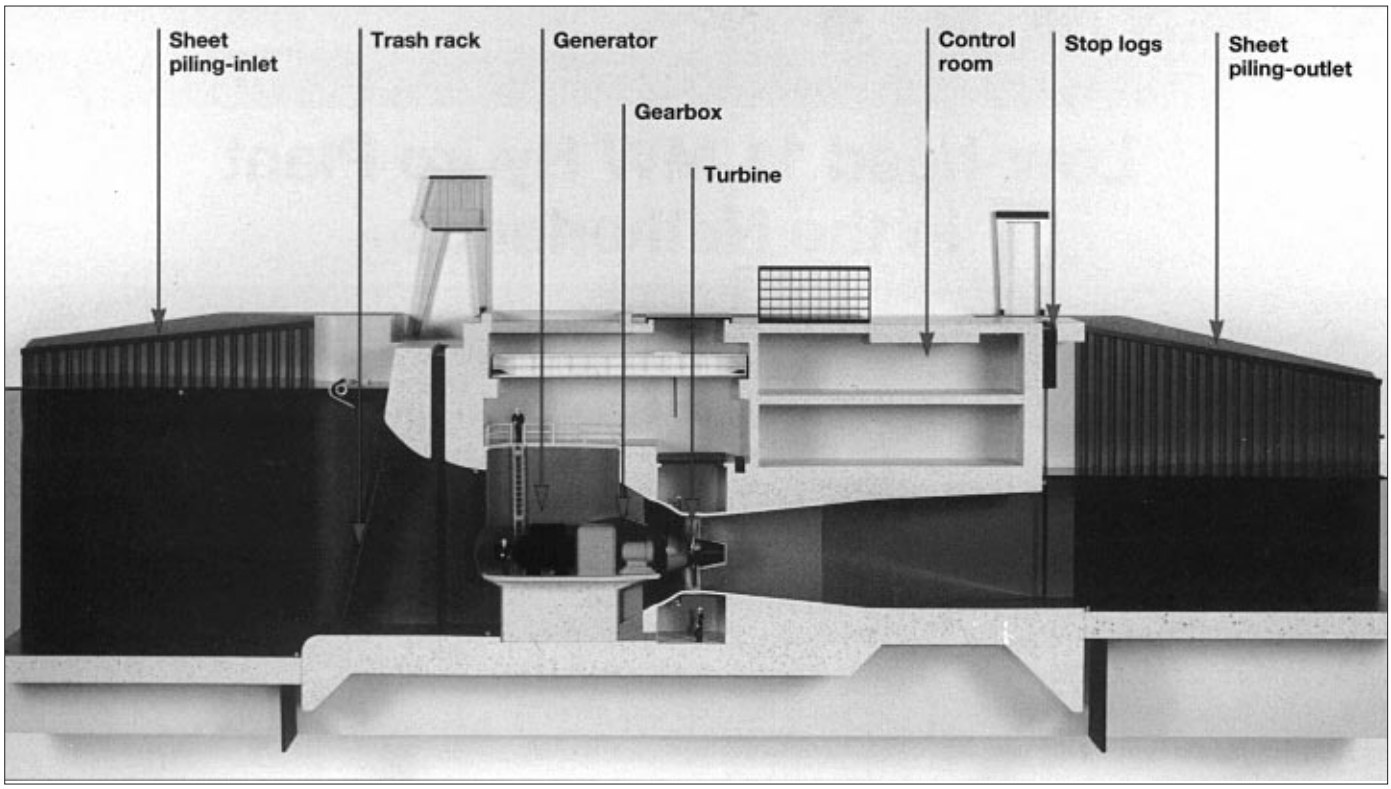
After a number of feasibility studies, the weir at Linne, in the Netherlands was selected as the best site for an 11 MW hydro-power plant on the river Maas. The plant was constructed between 1987 and 1989. During the following years an average of 31 GWh of electricity was produced each year. This was 20 GWh/year lower than expected due to the unexpected fluctuation in the water level during the years the project was monitored. Technically, the plant functioned well. Another characteristic of the project is the great care given to environmental aspects after the plant was built.

Highlights

- **Production of 31 GWh of electricity per year**
- **Environmentally friendly construction and operation**
- **Utilisation of a low-head weir**

The Hydro Station at Linne.

Photograph courtesy of KLM aerocarto airphotography, Schipol.



Section through the Hydro Station.

Project Background

The possibilities of hydro-power plants on the River Maas (the Meuse) have been studied repeatedly since the 1920s. Until quite recently, the economic feasibility of such plants was poor, mainly due to the low prices of fossil fuels. The rapid increase in the prices of fossil fuels in the 1970s, the official policy of fuel diversification and public interest in the environmental aspects of power generation stimulated a revaluation of the hydro-power option in the Netherlands. As a result, ten locations were found to be suitable for hydro-power stations. The best location was at the weir at Linne, on the River Maas, which was selected as the site for an 11 MW hydro plant. Construction of the plant began in 1987 and the plant came into operation in 1989.

The Project

In the design stage of the project, several functions of the River Maas had to be taken into consideration:

- it plays an important part in the soil hydrology of the southern Netherlands and Belgium, since it provides the major discharge channel for rain water from the Ardennes;
- it is an important traffic route;
- it supplies drinking water to households, industry and agriculture;
- it has an important influence on local ecology;
- it is used for recreation.

During both the construction and operation of the hydro plant care has been taken to minimise any interference with these functions.

The hydro plant at Linne was situated next to the weir where the average difference in water level is about 4 m, sufficient for the installation of 3.5 MW Kaplan turbines. The plant was constructed inside a 24,000 m^3 caisson built on the river bank and sunk into the ground to a depth of 21 m. Most of this work took place below the ground water level, which required the working space to be pressurised to about 2 bar. The health and safety hazards which this posed to the workers were an important issue.

Four Kaplan turbines, each of 4 m diameter with a nominal power of 2.87 MW (maximum power of

Table 1: Performance over the years 1992 to 1994		
	Electricity production GWh/year	Primary energy savings TJ/year
1992	37	325
1993	26	226
1994	32	281

3.5 MW), make up the plant. Each turbine is connected to the generator by a gearbox which converts the 88.23 rpm of the turbine into the 750 rpm necessary to drive a generator. In principle, the plant has a maximum power output of 11.5 MW at a head across the turbines of 4 m and a water flow of 450 m^3/hour. At average conditions, the plant should produce about 52 GWh of electricity each year.

A characteristic of this project has been the care and consideration which were given to environmental aspects. At the start of the construction work, rare varieties of plants were carefully removed from the site, stored in a depot and replanted after the work was finished. Specific care was given to the restoration of the original flora and fauna at the site and the creation of a good environment for amphibian animals such as toads and salamanders.

Several measures have been taken to prevent the power plant from being damaged by solid materials in the river and to prevent the ecology of the river from being damaged by the power plant. To prevent damage to the turbines, a trash rack has been placed across the turbine inlet. A fish ladder was built alongside the plant so that fish movements are not impeded.

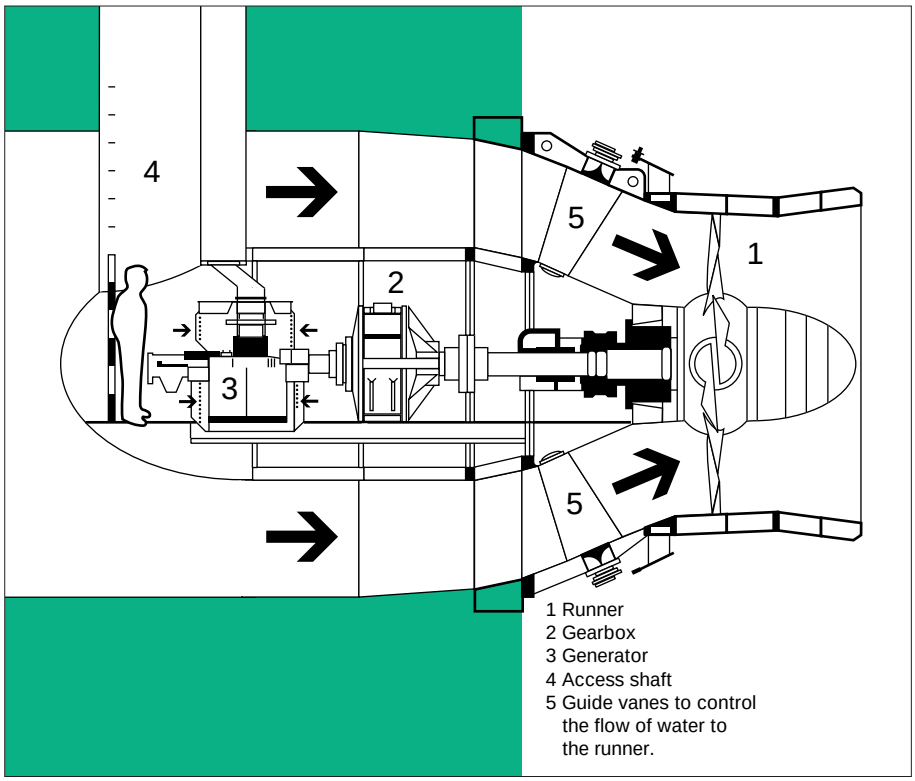
Performance

Plant performance over the years 1992 to 1994 is shown in Table 1. Primary energy savings have been calculated by reference to a conventional power station with 41% efficiency. The average electricity production is about 31 GWh/year. This is less than the expected production of 52 GWh/year. During the years concerned, the water level in the Maas has been either too low or too high for prolonged periods. When it is too low, the head across the turbines does not allow any power production; when it is too high, the weir gates are opened, and the head disappears altogether.

Economics

The total investment for the plant amounted to NLG71 million (where NLG is the Netherlands guilder). The value of the annual electricity production of 31 GWh is about NLG5.3 million/year. Since the costs of maintenance and of operation are minimal, this figure can be used to calculate the simple payback period of 13 years. This is acceptable, given the expected life span of the plant of 40 to 50 years.

Table 2: Technical Details	
General information	
Upstream level	20.80 m
Maximum head	4.00 m
Average river flow	250 m^3/s
Maximum flow through power station	450 m^3/s
Total rating	11.5 MW
Units	4 x 2.87 MW
Design life	40 to 50 years
Transmission	
Type	Single-stage planetary gearbox
Turbine	
Type	Horizontal, dual-control Kaplan
Runner diameter	4 m
Maximum power	3.5 MW at 102.5 m^3/s
Speed	88.23 rpm
Generator	
Rating	4175 kVA
Voltage	10.5 kV
Speed	750 rpm



Section through a Kaplan turbine.

Host Company
MEGA Limburg
(Formerly: PLEM)
PO Box 3920
6202 NX Maastricht
The Netherlands
Tel: +31 43 855 555
Fax: +31 43 855 531

Monitoring Agency
Novem
PO Box 17
6130 AA Sittard
The Netherlands
Contact: Mr W van Zanten
Tel: +31 46 595 329
Fax:+31 46 528 260

Please write to the address below if you require more information.

CADDET Centre for Renewable Energy
ETSU, Harwell
Oxfordshire OX11 0RA
United Kingdom
Tel: +44 1235 432719
Fax: +44 1235 433595
E-mail: caddet.renew@aeat.co.uk

International Energy Agency
The International Energy Agency (IEA) is an autonomous body which was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

Printed on environmentally friendly paper.

CADDET
CADDET was set up in 1988 as an IEA Centre for the Analysis and Dissemination of Demonstrated Energy Technologies. Today, there are two CADDET operations: one is for energy-efficient technologies and the other for renewable energy technologies. The Centres co-operate with member countries in the exchange of high quality information on energy technologies.

See the whole range of CADDET Renewable Energy projects on www.caddet-re.org

NL 95 505 First printed 1995