(57) Abrégé/Abstract:
Power plant comprising: a lower level reservoir, a feed-through (line, hose, pipe, channel) for fluid communication from the lower level reservoir to a higher level reservoir, characterised by a pump arranged in connection with the feed-through in order to pump
(57) Abrégé(suite)/Abstract(continued):
water from the lower level reservoir to the higher level reservoir in order to store energy by emptying the lower level reservoir, and a turbine/generator for power production arranged in or at the lower level reservoir in connection with said feed-through, or additional feed-through, for fluid communication between the lower level reservoir and the higher level reservoir for power production during flow of water from the higher level reservoir to the lower level reservoir. A method for power production. Use of the power plant.
Title: POWER PLANT, METHOD FOR PRODUCING POWER, AND APPLICATION OF SAID POWER PLANT

Abstract: Power plant comprising: a lower level reservoir, a feed-through (line, hose, pipe, channel) for fluid communication from the lower level reservoir to a higher level reservoir, characterised by a pump arranged in connection with the feed-through in order to pump water from the lower level reservoir to the higher level reservoir in order to store energy by emptying the lower level reservoir, and a turbine/generator for power production arranged in or at the lower level reservoir in connection with said feed-through, or additional feed-through, for fluid communication between the lower level reservoir and the higher level reservoir for power production during flow of water from the higher level reservoir to the lower level reservoir. A method for power production. Use of the power plant.
Power plant, method for producing power, and application of said power plant

Scope of this invention

This invention relates to production of energy. Furthermore, the invention relates to a power plant, a method for power production and utilization of the power plant according to the invention. The power plant according to the invention is particularly suitable for storage of surplus power or cheap power for subsequent power production.

Background and prior art of the invention

Stable access to energy is necessary for the modern society. Out of consideration to the environment, many are today concerned about sustainable energy, for instance obtained from wind, waves, tidal currents, sea currencies, geothermal deposits or salt-water gradients. Utilization of a number of such energy sources can for instance be combined in marine energy parks, and since different energy sources partly can be utilized complimentary, uniform production and savings with regard to developing and operating costs can be obtained. Still, the energy production tends to vary, and there is a need to store surplus energy. Similarly, there is a need for a simple way to store cheap energy from energy sources or power plants of any known type, including surplus energy from industrial plants. Different power plants and industrial plants attend to have an uneven energy production which is not correlated with the consumption.

A pumping storage power plant is known as technology, and is the method of storage of energy that presently give the highest efficiency. In a pumping storage power plant water is pumped to an elevated reservoir in periods with surplus production or in periods with low energy prices, whereupon energy is produced by letting water escape from the elevated reservoir through turbines located at a lower level. Furthermore, there are means to dam up water at flood tide and to let out water through turbines at low tide. Examples of known devices may be found in the patent publications US 3 487 228 and BE 903837.

There is a need for alternative power plants, methods and uses of power plants having advantageous properties compared to prior art devices. There is particularly a need for pumping storage power plants which are particularly suitable in marine environments.

Summary of the invention

The above mentioned needs are met by the present invention, where the invention provides a power plant comprising:
a low level or low-lying reservoir

a feed through (line, hose, pipe, channel) for fluid communication from the low level reservoir to a high level or high-lying reservoir,

characterised by a pump arranged in connection with the feed through in order to pump water from the low level reservoir to the high level reservoir in order to store energy by emptying the low level reservoir, and

a turbine/generator for power production arranged in or at the low level reservoir in connection with the mentioned feed through or an additional feed through for fluid communication between the low level reservoir and the high level reservoir for power production during flow of water from the high level reservoir to the low level reservoir.

By the term low level reservoir is meant a reservoir where the water level at any time is lower than the water level in the high level reservoir or a reservoir where the highest possible water level equals the water level in a high level reservoir, such as a volume delimited from an external sea level.

The invention also provides a method for power production by using the power plant according to the invention, characterised by pumping out the water with the pump from the low level reservoir by means of surplus power or cheap power during periods of time when such power is available, and introduce water from the higher level reservoir to the lower level reservoir in periods of time when the price of power is high or when there is a need for the thus stored power for producing power in the turbine/generator.

Furthermore, the invention provides for the use of a power plant according to the invention for storing surplus power or cheap power for subsequent power production according to the need.

**Figure**

The present invention is illustrated by means of Figure 1 that illustrates the power plant according to the present invention.

**Detailed description**

Reference is made to Figure 1 which illustrates the power plant according to the invention, as well as the method and the use according to the invention.

Specifically, 1 illustrates the power plant in storage mode, meaning that the water level in the lower level reservoir is lowered due to use of surplus energy or cheap energy for pumping water from the reservoir, while 2 illustrates the plant in production mode, that is when water is introduced via a turbine for thus to produce energy. In the figure A indicates the lower level reservoir, B indicates both pump and turbine/generator for power production, while C indicates a valve. The higher level reservoir is situated outside the lower level reservoir. The higher level reservoir is preferably the sea while the lower level reservoir preferably a tank positioned at the
seabed, which typically has previously been used for another purpose. In the illustrated embodiment only one feed-through (line, hose, pipe, channel) is present which is thus used to pump out water from the lower level reservoir and feed water from the higher level reservoir during subsequent power production. Alternatively separate feed-throughs or lines for alternatively pumping out water and introducing water is arranged, having a pump in a connection with the feed-through for out-pumping, and turbine/generator in connection with the feed-through for introducing water from the higher level reservoir. In the illustrated embodiment the valve C is arranged in a branch-line from the feed-through. In storage mode, illustrated by 1, the valve C is closed while the valve, in production mode 2, is open to introduce water from the higher level reservoir. When using one feed-through the pump can likewise be separated in a dedicated branch-line from the turbine/generator, as convenient. The outlet for out-pumped water is preferably just above the water surface in the higher level reservoir in order to minimize the pumping effort. The outlet from the turbine is preferably at a bottom level in the lower level reservoir in order to maximize the height of fall of water, independent of degree of filling in the lower level reservoir, and in order to reduce any problems with cavitation. The energy which can be stored is proportional with the product of out-pumped water volume and the obtained height of fall of water in production mode. In order to maximize the stored amount of energy, the cross-section of the lower level reservoir may be larger at to the bottom than at the top, which will create a large height of fall of water for larger volumes. Several lower level reservoirs can be interconnected, which may be advantageous in connection with building work and mechanical loads. In a preferable embodiment the entire lower level reservoir is at a level below the water surface. In one embodiment the lower level reservoir is preferably a part of a foundation for a field centre, or anchoring or foundation for other energy producing devices. In a preferred embodiment the lower level reservoir is a re-use of previous, differently used devices, for example former storage tanks for oil, storage tanks or shafts for oil- and gas platforms or even pipe lines. A particularly advantageous embodiment is to arrange the lower level reservoir in tanks and perhaps also on the shaft on one or several interconnected gravity based structure-platforms such as concrete tanks and one or several hollow concrete shafts in a seabed positioned platform. One embodiment, which particularly can be suitable along coasts with suitable topography, is to dam up in an area, wherein the area constitutes the lower level reservoir. Another preferred embodiment is to operate the lower level reservoir to also function as wharf or an area for other applications, where a cover with ventilation preferably is arranged at the upper part of the lower level reservoir. A further advantageous embodiment is to apply hollow spaces onshore, which is close to the sea, and in a level below the sea surface, as the lower level
reservoir, for example cave, caverns or hollow spaces from a terminated mining operation.

The pump is preferably also arranged in a bottom level in the lower reservoir since such a location will provide a certain inlet pressure and reduction of any cavitation problems. Increased pump head is compensated by increased inlet pressure.

For a turbine arranged at the bottom level, or at the bottom of the lower level reservoir, increased pressure at the outlet side is compensated by increased height of fall of water.

The turbine/generator may however be arranged on a floating body, where water supply preferably is provided via flexible pipes such as in the form of hoses or telescopic pipes. The pump may also be arranged on or attached to such floating body, having attached feed-throughs in the form of flexible pipes. Structural benefits, and advantages with regard to access and maintenance, may thus be achieved.

The pumps may be chosen among pumps that are driven electrical, directly mechanical, or mechanical via gear connections or hydraulic, as the available surplus energy or cheap power will determine which choice is suitable to achieve a high efficiency, low investment costs, good operation safety and simple maintenance and replacement according to good engineering practice. In order to reduce loss of efficiency, the pump may be driven mechanically, directly or hydraulic, by wind power, wave power and/or sea current power. Pumps, turbines, generators, valves and types of pipes or similar will not be further described herein since it is considered within prior art and good engineering practice to undertake suitable choices and arrangement of such known equipment within the framework of the description and attached claims.

The power plant according to the invention can both store and produce energy and is particularly advantageous if it is arranged as part of a large energy plant. For example the transfer capacity in cables from a plant for offshore power production may be reduced by storing the peak production as energy in a power plant according to the invention. In such an offshore plant, water, waves and current in the sea can generate energy under normal operational conditions, However, during high regular production a part of the produced energy will be stored in a power plant according to the invention, while at low regular production the power plant according to the invention can be put in operational mode for production of the storage energy.
Patent claims

1. Power plant comprising:
   a lower level reservoir,
   a feed-through (line, hose, pipe, channel) for fluid communication from the
   lower level reservoir to a higher level reservoir, characterised by a pump arranged in
   connection to the feed-through for pumping water from the lower level reservoir to the
   higher level reservoir in order to store energy by emptying the lower level reservoir, and
   a turbine/generator for power production arranged in or at the lower level
   reservoir in connection with said feed-through, or additional feed-through, for fluid
   communication between the lower level reservoir and the higher level reservoir, for
   power production during flow of water from the higher level reservoir to the lower
   level reservoir.

2. Power plant according to claim 1, characterised in that the
   turbine/generator is arranged at the bottom level in the lower level reservoir.

3. Power plant according to claim 1 or 2, characterised in that the pump
   being arranged at the bottom level in the lower level reservoir.

4. Power plant according to claim 1, characterised by the lower level reservoir
   being arranged at a sea level, wherein the sea constitutes the higher level reservoir.

5. Power plant according to claim 1, characterised in that the lower level
   reservoir is arranged in tanks and/or in the shaft of a gravity based structure installation
   or a seabed positioned tank previously used for storage of fluid such as oil.

6. Method for power production by using the power plant according to claims
   1-5, characterised by pumping out water with the pump from the lower level reservoir
   by means of surplus power or cheap power in periods of the time when such power is
   available, and introduce water from the higher level reservoir to the lower level
   reservoir in periods of time when the price of power is high, or when there is need for
   the thus stored power, in order to produce power in the turbine/generator.

7. Use of the power plant according to claims 1-5, for storage of surplus power
   or cheap power, when such power is available, for subsequent production.