Renewable and Sustainable Energy Reviews 34 (2014) 174–184

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Offshore hydroelectric plant: A techno-economic analysis of a renewable energy source

Cawas Phiroze Nazir*

Consulting Engineer, 5A Dilkusha Street, Kolkata 700017, India

ARTICLE INFO

Article history:
Received 1 September 2013
Received in revised form
31 January 2014
Accepted 1 March 2014

Keywords:
Renewable energy
Offshore engineering
Power station

ABSTRACT

In a world where fossil fuel prices are subject to steep price hikes and where green house emissions are endangering the planet, dependence on non-renewable energy sources becomes more urgent. In this paper a technical feasibility and economic viability study of a new technology that utilizes hydroelectric power to tap the oceans' enormous energy reserve is presented. Called the Offshore Hydroelectric Plant, such an installation has an underwater powerhouse, the water from the turbines being discharged into a tail race sump (TRS). Power is generated when suitable head is created between the TRS and the sea, by leading the water out and allowing it to flow into giant troughs located in a vertical elevator building. Here, hoists raise the troughs carrying the excess water and empty them into an overhead tank (OHT). Water from the OHT is carried by penstocks to another powerhouse located at sea level. The plant utilizes the existing technologies of tidal plants, vertical ship lifts, and pumped storage schemes. Well-developed technologies of the offshore oil industry are utilized in fabricating the structures on shore, and towing them to location. An example demonstrates that a 104 MW plant could produce 569 GWh annually. Project investment costs are approximately $ 432 million and Levelized Electricity Costs $0.055/kWh.

Contents

1. Introduction . . . 175
2. Overall concept . . . 176
   2.1. Working principle . . . 176
3. Preliminary design . . . 176
4. Detailed plant design . . . 177
   4.1. PH1 . . . 177
   4.2. TRS . . . 177
   4.3. EB . . . 177
      4.3.1. Description of maneuvering . . . 177
   4.4. OHT . . . 178
   4.5. CGS 1 . . . 178
   4.6. PH2 and CGS2 . . . 178
   4.7. Grid connection . . . 178
5. Example . . . 179
   5.1. PH1 . . . 179
      5.1.1. PH1 civil and equipment cost $ million . . . 180
   5.2. TRS . . . 180
      5.2.1. TRS civil cost $ million . . . 180
   5.3. EB . . . 180
      5.3.1. Winch drive . . . 180
      5.3.2. HP required . . . 180

* Tel.: +91 332 290 6129.
E-mail address: cpnazir@gmail.com

http://dx.doi.org/10.1016/j.rser.2014.03.006
1364-0321/

5.3.3. Civil and equipment cost $ million . . . 181
5.4. OHT . . . 181
5.4.1. OHT civil cost $ million . . . 181
5.5. CGS1 . . . 181
5.5.1. CGS1 civil cost $ million . . . 181
5.6. PH2 . . . 181
5.6.1. PH2 civil and equipment cost $ million . . . 182
5.7. CGS2 for power house 2 . . . 182
5.7.1. CGS2 civil cost $ million . . . 182
5.8. Grid connection . . . 182
5.9. Other costs . . . 182
6. Costs of OHP . . . 182
6.1. Overnight construction costs . . . 182
6.2. Capacity factor . . . 182
6.3. Annual generation . . . 182
6.4. Levelized electricity costs . . . 183
7. Results and discussions . . . 183
7.1. Construction costs . . . 183
7.2. Cost comparison . . . 183
7.3. Flow rate . . . 183
7.3.1. The size of troughs to transport water would depend on practical considerations . . . 183
7.3.2. As regards speed of travel, a conservative value of 1.5 m/s has been assumed . . . 183
7.4. Head difference . . . 183
7.5. Scale up . . . 183
7.6. Clean energy . . . 183
8. Conclusions . . . 183
References . . . 184

1. Introduction

In the quest for renewable energy, the oceans provide an enormous potential. There are primarily two types of ocean energy [1]: thermal energy from the sun's heat and mechanical energy from the tides and waves. Wave energy is created as winds pass over open bodies of water, transferring some of their energies to form waves which can be captured by wave conversion technologies to provide power. Wave energy [2] is considered as a major and promising renewable source. McFall [3] describes a system where a buoy riding the up and down motion of waves drives a piston which in turn draws sea water. The water is forced up a pipe to a storage tank placed at a height from where it is discharged through a turbine to generate electricity. Biteryakov [4]

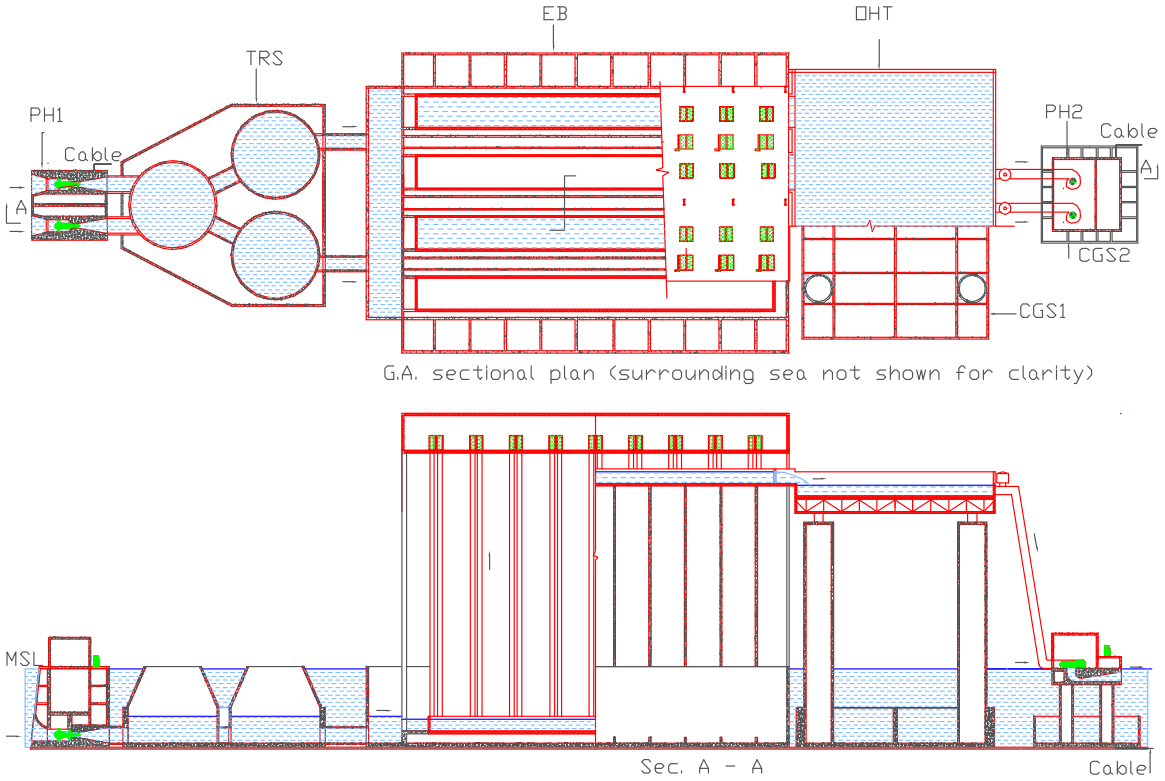

Fig. 1. G.A. plan and longitudinal section of Offshore Hydroelectric Plant.