High-rise Building Micro-hydro Pumped-storage and PV Micro-grid Proposal with Shanghai Jinmao Tower as a Case Study

Jianmin Zhang¹, Qianzhi Zhang²

¹ Hangzhou Dianzi University, Hangzhou, China; ² Schl. of Elect., Comput., and Energy Engi., Arizona State University, USA

Introduction

Electrical load is centralized in city, especially in high-rise building which not only has PV or Wind generation resource but also has a great gravity potential. The building above 50 meters are everywhere in city, there are 17383 buildings above 90 meters in the world. Water is also a necessary resource that city should have; water storages in the roof, or water bodies in waist, and water tanks underground of a building or a building group, are not difficult to build them, in fact, water systems including pump system have already been implemented in those buildings for water drink, sanitation, swim pool, fire control, water drain, etc. The hydro pumping storage will only add some new spaces, weight-bearing, new mini hydro pumping systems, etc. A micro-grid development scheme of mini-hydro pumping with PV or others is surveyed and it seems feasible from technical as well as economic point of view.

High-Rise Building Resources in the World

- Numbers of Blvd above 90m of Country over 100 Blvds (World total 17383)
- Top 20 City Rank of Number of Building over 90 m
- Numbers of Blvd above 90m of top 20 Cities
- Top 20 High Rise Building in the World

Roof Garden Burden: Typical Operation Mode, 3 turns of pump generating (40*402 TopTank)

Parameters of Shanghai Jinmao Building

Bld Parameters:
Height: 420.5m
Section Area: 100m*100m

Electrical Parameters (Top Reliability):
Volt: 33kV/3.6kV/380/220V
Incoming: 235kV Independent Lines
Main Transformers: 1*10MV
Static Load: 10MV, so 3 Transf backup Emer.Stanby Gen: 6*1094 kW Oil

Present Shanghai Electricity Price Table

Valley 22pm – 5am : 0.273;
Ave 6-7, 11-12am/15-17, 21pm : 0.719;
Peak 8-10am/13-14, 18-20pm : 1.202.

Turbine/Pipe/Generator/Pump Efficiency

Turbine efficiency : 0.9; Generator efficiency : 0.92
Pump efficiency : 0.8; Global Efficiency : 0.6624.

Hydro-Pump Parameters Optimal Selection for grid-tied operation under weight bearing of roof garden standard

Table 1. The re-use case return for different top tank design under the garden standard of burden.

Contact information

• Prof. Jianmin Zhang, Col. of Automation, Hangzhou Dianzi Univ., Hangzhou 310018 China, zhangjmhzcn@hdu.edu.cn
• Mr. Qianzhi Zhang, Research Assistant, MSEE, Schl. of Elect., Comput., and Energy Engi., Arizona State Univ., Tempe, AZ 85287-5706, USA zhangqianzhi@asu.edu

Economic Evaluation for Roof Garden Burden (40*402 TopTank)

Hydro capacity: 2400kW. 37% of the standby gen; set;
Pump capacity: 3600 kW. Total investment: 40.0k ¥
Daily return: 2800 ¥, Annual 10.22k ¥, 4 Years return

It seems a very good investment.

Results for weight bearing over the garden enclosed under Top Water Tank. bottom section in 50m*50m

Photovoltaic Pumped-hydro Storage + Sensitive Load Isolated Operation Mode

PV Curve: Total Gen. 4470 kWh
Sets Load Curve: Total 3730 kWh

Hydro-PV Curve: Total 645.46kWh
Pump Load Curve: Total 2951.72kWh

Mismatch: Shortage of Power Supply: 223.26 kWh, 5%