

## Investigation of Pumped Storage Hydro Power Plant

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### **Abstract:**

Designed to meet the increasing energy demand and provide a sustainable alternative for energy storage and generating, the Ghatghar Pumped Storage Plant (PSP) is a historic hydroelectric project. Operating since 2008, the plant guarantees effective and quick construction by employing an inventive dual-reservoir system with an upper and lower dam built using Roller Compacted Concrete (RCC) technology. The 250 MW facility uses cyclical water transfer to store energy during off-peak hours and produce electricity at peak demand, therefore using the ideas of pumped storage. Modern elements include Francis turbines, steel-lined pressure shafts, and an underground powerhouse with sophisticated generator units and transformer systems abound in the architecture of the facility. The building of the project created major difficulties including the relocation of settlements and exact engineering of water conductor systems, tail race tunnels, and ancillary buildings. Acquired overall 320.096 hectares of land, reconciling social and environmental concerns with development demands. Faster, less expensive, and high-quality dam building was made possible by RCC technology and specialized equipment like stacker conveyors and high-pressure water blasters. During peak demand, the plant runs six hours daily producing 1.5 million units (MUs) of electricity and yearly grid contribution of 469.5 GWh. It is a vital part of energy load control as it pumps water for seven hours daily during off-peak times using more than necessary power. Beyond just its technical prowess, the Ghatghar PSP demonstrates how well sophisticated engineering, sustainable energy sources, and social responsibility are incorporated. This research emphasizes how important pumped storage facilities are to solve world energy issues, promote grid stability, and enhance renewable energy sources complementing each other. Modern energy systems are modeled after it, which strikes a mix of sustainability, economy, and community effect.

**Keywords:** Pumped Storage Plant, Renewable Energy, Roller Compacted Concrete, Energy Storage, Francis Turbine, Hydro Power, Sustainable Energy, Ghatghar PSP, Dual Reservoir System, Energy Management.

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## I. INTRODUCTION

The world is moving toward renewable energy sources as a sustainable solution driven by the always growing global energy demand, the depletion of fossil fuel reserves, and the negative effects of climate change. Among them, one of the most dependable and effective ways of energy storage and generating is hydroelectric power as well as especially pumped storage plants (PSPs). Pioneering project in India, the Ghatghar Pumped Storage Plant shows how clever building methods combined with renewable energy sources may help to solve the energy issue. Since 2008, this facility not only displays technical

creativity but also emphasizes the need of renewable energy in guaranteeing world economic and environmental stability.

Environmental advantages and long-term sustainability of renewable energy sources—including solar, wind, tidal, hydro—have helped them to become very popular. Understanding this, the Indian government has aggressively supported renewable energy projects and started many programs aiming at the acceptance of such technology. One of the most developed and extensively utilized renewable energy sources, hydro power has been rather important in the scene of India's electricity. Micro, mini, and tiny hydro categorization of hydro projects has helped to further allow focused development plans. India has shown its will to strike a balance between energy production and environmental preservation and social responsibility via PSPs such as Ghatghar.

Operating on the dual functionality concept, the Ghatghar Pumped Storage Plant provides both energy storage and generation of electricity. Water from the top reservoir moves down to the bottom reservoir during peak demand hours, generating generators to provide power. On the other hand, extra grid electricity is utilized to pump water up to the higher reservoir during off-peak hours, therefore producing a cyclical process improving energy storage efficiency. Modern energy systems depend on PSPs as this creative solution lets them control grid loads, change frequency, and provide emergency power. Using sophisticated Francis turbines at Ghatghar guarantees great efficiency, even under different running circumstances, therefore highlighting the technical excellence of the facility.

The Ghatghar PSP was a massive project requiring rigorous social and environmental concerns, excellent engineering, and thorough planning based on much effort. The three dams the project built—the upper, saddle, and lower dams—using Roller Compacted Concrete (RCC) technology. Renowned for its speed, economy, structural soundness, and cost-effectiveness, RCC technology was absolutely vital for the plant's development. The project also required the building of RCC cooling systems, aggregate crushing facilities, and effective manufacturing and delivery systems. Stressing the plant's technical expertise, the utilization of specialist tools like double axle dump trucks, stacker conveyors, and high-pressure water blasters guaranteed accuracy and quality in RCC installation.

Apart from the scientific and engineering successes, the Ghatghar PSP addresses social and environmental issues, therefore reflecting a balanced approach to development. Land purchase for dam building and related infrastructure needed careful planning and evacuation of impacted settlements. Purchased from locations in Ahmednagar and Thane districts, 320.096 hectares—including private and forest land—were obtained overall. Sensitive handling of the relocation procedure guarantees that displaced people will get sufficient compensation and resettlement possibilities. This emphasizes the requirement of social responsibility in major infrastructure projects, as growth has to balance with the demands of nearby ecosystems and populations. Finally, the Ghatghar Pumped Storage Plant stands as an amazing junction of social responsibility, modern engineering, and sustainable energy sources. It greatly helps India's renewable energy targets by attending to the vital need for effective energy storage and production. Projects like Ghatghar show how to combine technical innovation with sustainable development as the globe works through energy issues and climate change. The success of the plant highlights the possibilities of pumped storage technology in addressing the complexity of social and environmental effects and therefore help to shape a better, more resilient energy future.

## **II.HISTORY OF PUMPED STORAGE POWER PLANTS IN THE WORLD**

Pumped storage power plants (PSPs) are among the most enduring and versatile forms of energy storage, with a history dating back over a century. These systems have been pivotal in balancing energy demand and supply, ensuring grid stability, and integrating renewable energy sources into modern power systems. The evolution of PSPs reflects the progression of engineering innovations, environmental considerations, and energy policies globally.

### **A. Early Developments and the Concept of Pumped Storage**

The concept of pumped storage can be traced back to the late 19th century when electricity demand began to fluctuate significantly with industrialization and urbanization. Early hydroelectric systems, primarily built to generate electricity from flowing water, revealed the need for energy storage to address demand variations. In 1907, the first recorded pumped storage power plant was commissioned in Switzerland at the **Linth-Limmern facility**, where excess energy was used to pump water to an elevated reservoir for later use. This pioneering project demonstrated the potential of PSPs in energy management.

By the 1920s, PSPs gained traction in Europe and North America as electricity grids expanded. The Raccoon Mountain project in the United States and the Zwitserland facility in Austria were among the early adopters of this technology. These plants showcased the efficiency of storing energy during off-peak hours and supplying it during peak demand, making them indispensable in maintaining grid reliability.

### **B. Post-World War II Expansion**

The post-World War II era marked a significant expansion of pumped storage plants worldwide. The rapid growth of industrial activity and urban centers created a pressing need for large-scale, reliable energy storage systems. PSPs became an attractive solution due to their scalability and ability to support growing electricity grids.

In Europe, nations like Germany, France, and the United Kingdom led the development of large-scale PSPs during the 1950s and 1960s. The Coo-Trois-Ponts facility in Belgium and the Ffestiniog station in Wales were notable projects from this period. These plants utilized advancements in turbine technology and hydraulic engineering to achieve higher efficiency and capacity.

The United States also embraced pumped storage technology during this period. The Bath County Pumped Storage Station, commissioned in 1985 in Virginia, became the world's largest PSP with a capacity of 3,003 MW. Its design highlighted innovations in reversible pump-turbine technology, allowing seamless transitions between pumping and generating modes.

### **C. Modernization and Global Adoption**

The 1970s energy crisis and the subsequent shift toward renewable energy accelerated the development of PSPs worldwide. Countries recognized the potential of PSPs in complementing intermittent renewable energy sources like solar and wind. This led to the construction of larger and more sophisticated facilities.

In Asia, nations such as Japan and China emerged as leaders in pumped storage technology. Japan's pumped storage plants, including the Okutataragi and Kannagawa facilities, exemplify cutting-edge engineering. These projects were designed to address the challenges posed by Japan's mountainous terrain and limited land availability. China, too, has invested heavily in PSPs, with facilities like the Huizhou Pumped Storage Plant supporting its growing renewable energy infrastructure.

Similarly, Europe continued to expand its pumped storage capacity to meet the increasing demand for renewable integration. Projects like the Goldisthal Pumped Storage Station in Germany, commissioned in 2003, combined environmental sensitivity with engineering excellence. It featured underground reservoirs and eco-friendly designs, setting new benchmarks in PSP construction.

#### **D. Pumped Storage in the Renewable Energy Era**

The 21st century has seen PSPs play a pivotal role in the global transition to renewable energy. With the rise of solar and wind power, the intermittent nature of these sources created a need for reliable energy storage. PSPs emerged as a key solution, capable of storing excess renewable energy and supplying it during peak demand or low generation periods.

In Australia, the Snowy 2.0 project aims to increase the country's energy storage capacity and facilitate the integration of renewable sources. In South America, Brazil's Belo Monte hydroelectric complex includes pumped storage capabilities to balance its energy system. African nations are also exploring PSPs to address energy access challenges and renewable integration.

Modern PSPs incorporate state-of-the-art technologies to improve efficiency and reduce environmental impact. Variable-speed pump-turbines allow plants to operate at optimal levels under varying grid conditions. Underground and modular PSP designs minimize land use and environmental disruption. Additionally, digital monitoring and control systems enhance operational flexibility and reliability.

The development of hybrid PSPs, integrating batteries with traditional storage methods, represents another innovation in this field. These systems combine the long-term storage capacity of PSPs with the rapid response capability of batteries, making them well-suited for modern grid requirements.

The future of PSPs lies in expanding their role in sustainable energy systems. Emerging markets in Africa, Southeast Asia, and Latin America are likely to witness significant growth in pumped storage capacity as these regions strive to achieve energy security and reduce carbon emissions. Additionally, research into advanced materials, turbine designs, and integration with other renewable energy systems will continue to enhance the efficiency and environmental sustainability of PSPs.

The history of pumped storage power plants is a testament to humanity's ability to innovate and adapt to changing energy needs. From early installations in Switzerland to modern mega-projects in China and the United States, PSPs have evolved to meet the demands of growing electricity grids and the transition to renewable energy. As the world seeks cleaner, more resilient energy systems, PSPs will remain a cornerstone of energy storage, balancing the fluctuating demands of the grid and supporting the widespread adoption of renewables. Their continued development reflects the critical role of sustainable engineering solutions in addressing global energy challenges.

### III. CONSTRUCTIONAL DETAILS OF THE PROJECT

Ghatghar Pumped Storage power plant is the largest pumped storage plant in the Maharashtra state. It is located on the river Pravara which is on the outskirts of Thane and Ahmednagar district in Maharashtra. The main idea behind this is to meet the increasing demands due to the industrial and population growth in the state of Maharashtra.

The capacity of the plant is 250 MW. The plant consist of two reservoirs, the first is Upper reservoir located at village near Ghatghar, Taluka Akole, District Ahmednagar and the second is the lower reservoir which is located near village Chonde, Shahpur taluka, District thane. The underground power house is located near the lower reservoir. This power house consist of two reversible pump turbines each of 125 MW. This plant ensures annual generation of 497 Mus with a operating head of 400m. The plant operates 6hrs daily for generation during peak hours excluding Sundays and operates 7hrs for pumping during off-peak hours excluding Sundays.

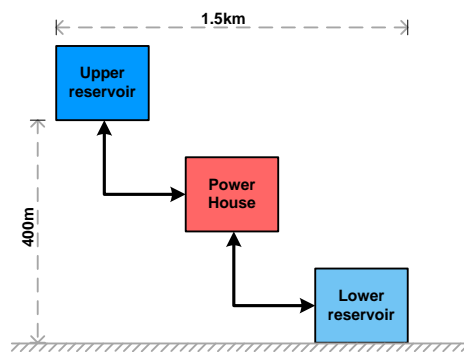


Fig. 1 Block Diagram of the system

#### a. Location

The plant is situated in two different areas as this is a pumped storage plant. The Upper reservoir located at village near Ghatghar, Taluka Akole, District Ahmednagar and the lower reservoir is located near village Chonde, Shahpur taluka, District thane.

Lower dam is located on Shai nalla near Chondhe village of Shahapur Tahasil in Thane District. Maximum Height of the dam above deepest foundation level is 86.14 m and length of the dam is 446.80 m. Storage capacity of the dam is 3.21 MCum. Stepped spillway having designed discharge 192.38 m<sup>3</sup>/sec & length 89m. The plant is 80Km from Mumbai, nearest airport is Mumbai Airport which is 126 Km, nearest seaport is 80Km away from the power plant.



Fig.2 Lower Dam

Upper Dam is located on River Pravara near village Ghatghar of Akola Tahsil in Ahemadnagar District. The gross storage capacity of the dam is 5.82 MCum. Maximum height of the dam above deepest foundation level is 15.165 m and length is 503 m.



Fig.3 Upper dam

### III. COMPONENTS OF THE PLANT

The Ghatghar Pumped Storage Plant is a sophisticated infrastructure project comprising several critical components designed to enable efficient energy storage and generation. These components collectively ensure the smooth operation of the plant and the ability to meet energy demands effectively. Below is a detailed description of each major component:

#### a. Dams

The plant consists of two reservoirs, the **upper reservoir** and the **lower reservoir**, separated by a distance of 1.5 kilometers. Both dams were constructed using Roller Compacted Concrete (RCC) technology, which enabled rapid construction while maintaining structural integrity.

- **Saddle Dam:**
  - Height: 11.5 meters
  - Length: 286 meters
- **Lower Dam:**
  - Height: 86.14 meters
  - Length: 446.80 meters

These dams store water for the pumped storage cycle, facilitating both power generation and energy storage.

#### b. Power House Complex

The powerhouse is the operational hub of the plant, housing critical machinery and systems. It includes:

- **Two turbine-generator units:** These are responsible for converting hydraulic energy into electrical energy and vice versa.
- **Three-phase transformers:** Essential for voltage regulation and power transmission.

- **Auxiliary blocks:** Located on either side of the machine hall, these blocks house support systems like emergency passages, cable ducts, and bus ducts.

#### c. Auxiliary Blocks

The powerhouse includes two auxiliary blocks:

- **Auxiliary Block 1:** Located on the service bay side, with dimensions **29 x 22.20 x 23.80 meters**.
- **Auxiliary Block 2:** Located on the vertical turbine (V.T.) side, with dimensions **19.475 x 23.40 x 24.80 meters**, excluding the sump pit.

These blocks provide space for auxiliary systems, emergency operations, and support facilities.

#### d. Transformer Hall

The transformer hall houses the transformers and serves as an interface between the power generation system and the grid.

- **Length:** 81.35 meters
- **Width:** 20 meters
- **Height:** 26 meters (from the service bay level)

The hall includes a passage that connects it to the machine hall, facilitating smooth operation and maintenance.

#### e. Tail Race Tunnel (TRT)

The tail race tunnel is a critical part of the water conductor system, responsible for channeling water from the turbines back to the lower reservoir.

- **Length:** 590 meters
- **Diameter:** 6 meters (circular shape)
- **Features:**
  - Concrete-lined tunnel.
  - Includes two concrete plugs at the junction of link tunnels and the tail surge well for structural integrity.

#### f. Water Conductor System

The water conductor system is an integral part of the plant, ensuring water flow between the reservoirs and the powerhouse. It includes:

- **Upper Intake Structure:** Facilitates water entry into the pressure shaft.
- **Steel-Lined Pressure Shaft:**
  - Length: 696 meters
  - Diameter: 4.25 to 3.5 meters

- **Tail Surge Well:**
  - Diameter: 11 meters
  - Depth: 137 meters
- **Emergency Gates:** Installed at both the upper and lower intake structures.
  - **Lower Intake Gate Dimensions:** 5.27 x 9.25 meters, weighing 110 tons, operated electrically.

These components are engineered to withstand high pressures and facilitate efficient water movement.

#### **g. Turbine Units**

The turbine units include essential components for hydraulic energy conversion:

- **Guide Vanes:** Regulate water flow to the turbine.
- **Guide Vane Operating Mechanism:** Ensures precise control of the vanes.
- **Servomotors:** Operate the guide vanes and other hydraulic systems.
- **Turbine Guide Bearing & Shaft Assembly:** Provides support and ensures smooth operation.
- Instrumentation and pre-commissioning testing ensure optimal turbine performance.

#### **h. Butterfly Valve (BFV)**

- Installed for controlling water flow in the TRT.
- Components include:
  - **BFV OPU Unit (Power Pack):** Ensures smooth operation.
  - Servomotor installation and operational checks for efficient functionality.

#### **i. Main Inlet Valve (MIV)**

- Controls water flow into the turbines.
- Features:
  - Installed servomotor and oil piping for automated operation.
  - Includes a control panel for operational checks and seamless integration.

#### **j. Motor Control Panels (MCC)**

The MCCs manage various systems within the plant, including:

- **Air Compressor System**
- **Head Cover Drainage Pump**
- **Cooling Water Booster Pump**
- **Sand Separator and Shaft Seal Systems** These ensure smooth operation of auxiliary and critical systems.

### k. Generator Units

The generator units convert mechanical energy from the turbines into electrical energy. Installation highlights include:

- **Lower and Upper Brackets:** Provide structural support.
- **Stator and Rotor Assemblies:** Ensure efficient power generation.
- **Bearings and Cooling Systems:**
  - Upper thrust and guide bearings.
  - High-pressure lubricating pump for effective cooling.
- **Other Features:** Brake jacks, dust collectors, and space heaters for operational efficiency.

The alignment of turbine and generator shafts ensures seamless energy conversion.

### l. Auxiliaries

Auxiliary systems provide additional support for plant operations:

- **Pumps and Control Panels:** Manage water flow and cooling.
- **ACLT Panels:** Operate at 400 volts with internal wiring.
- **Battery Backup:** Includes 110-volt DC batteries and three battery chargers for uninterrupted operations.
- **Transformers:** Two station auxiliary supply transformers and two unit auxiliary supply transformers.

The components of the Ghatghar Pumped Storage Plant represent a combination of advanced engineering and thoughtful design. From the dams and water conductor systems to the powerhouse and auxiliary facilities, every component plays a critical role in ensuring the plant's efficiency and reliability. This integrated system highlights the sophistication of modern hydroelectric plants and their contribution to sustainable energy solutions.

## IV. IMPORTANT FEATURES OF WATER CONDUCTOR SYSTEM

This plant has various features which makes it different from other power plants , few of them are listed below.

### a. Water utilization

Daily water utilization for power generation is around 1.607 mm<sup>3</sup>, design discharge is of around 74.80m<sup>3</sup>/sec. Also the water required for weekly generation is 2.346mm<sup>3</sup>.

### b. Reservoir Data

The catchment area of upper reservoir is 18.43 Km<sup>2</sup> and that of lower reservoir is 2.5 Km<sup>2</sup>. It has a dead storage of 0.68mm<sup>3</sup> for upper reservoir and 0.48 mm<sup>3</sup> for lower reservoir, live storage of 5.14 mm<sup>3</sup> for upper reservoir and 2.73 mm<sup>3</sup> for lower reservoir, with gross storage of 5.82 mm<sup>3</sup> for upper reservoir and 3.21 mm<sup>3</sup> for lower reservoir.

**c. Upper and Lower Intake**

The upper intake is open type R.C.C. Structure with 5/ bay trash rack & 3.90m \* 7.27 m Service gate while the lower intake is also open type R.C.C. Structure with 5/ bay trash rack & 5.27m \* 9.25 m Service gate.

**d. Power House**

Table No 1:- Power house details

Sr.no	Type	Underground
i.	Installation	250MW (2 x 125 MW)
ii.	Machine Hall (Auxiliary Block)	123.00m x 23.40 m x 46.80 m
iii	Transformer Hall	81.35 m x 20.00 m x 26.00 m

**e. Tail race tunnel**

The tail race tunnel is circular lined shaped, 590m in length and 6 meter in diameter.

**Pump Turbine & Motor Generator**

**i) Pump**

The pump-turbine is a dual-mode machine that works as a **pump** (to store energy) and as a **turbine** (to generate energy). Key specifications:

**General Details**

- Type:** A **Francis turbine** is chosen for its high efficiency and ability to handle both pumping and generating modes.
- Units:** Two pump-turbine units are used to ensure redundancy and flexibility in operation.
- Elevation:** The center of the pump-turbine is positioned at 260.00 meters above a reference point.

**Operating Modes**

- Turbine Mode:** Converts potential energy of stored water into electricity.
  - Operates at a **design head** of 410 meters and **discharge** of 37.40 m<sup>3</sup>/s.
  - Rotation is **clockwise**.
- Pump Mode:** Pumps water back to the reservoir using excess electricity from the grid.
  - Operates at a slightly higher **design head** of 430 meters and **discharge** of 30.40 m<sup>3</sup>/s.
  - Rotation is **counterclockwise**.

**Construction and Design**

- The **spiral case** is made of welded steel, ensuring durability under high pressure (68 Kgf/cm<sup>2</sup>).
- The runner (rotating part) is a **Francis-type** with 7 vanes, optimized for efficient energy transfer.

- Dimensions:
  - **Inlet diameter:** 1800 mm.
  - **Runner inlet diameter:** 3468 mm; **outlet diameter:** 1730 mm.

### Energy and Operations

- **Generation:** Operates for **6 hours daily** (except Sundays), producing 9.57 million units (MUs) of energy weekly.
- **Pumping:** Pumps water for **7 hours daily**, consuming 12.41 MUs of energy weekly.
- There's a net energy consumption due to inefficiencies in the system (pumping requires more energy than generation).

### ii) Motor-Generator

This machine alternates between being a motor (during pumping) and a generator (during power generation).

#### Generator Mode

- Converts mechanical energy from the turbine into electricity.
- **Output:** 147 MVA (Mega Volt Amperes) at **13.8 kV** voltage.
- **Current:** 6150 A, with a **power factor** of 0.9 (indicating some reactive power is used).

#### Motor Mode

- Drives the pump by converting electrical energy into mechanical energy.
- **Output:** 150 MW (MegaWatts) at the same **13.8 kV** voltage.
- **Current:** 6380 A, operating at a power factor of 1.0 (purely resistive load).

#### Purpose and Applications

1. **Energy Storage:** The pump-turbine system is integral to balancing electricity demand and supply by storing excess energy during low-demand periods (as potential energy in the reservoir).
2. **Load Balancing:** During high demand, the system generates electricity, ensuring grid stability.
3. **Efficiency:** While energy is lost in the process (pumping requires more energy than generating provides), the system's ability to store energy makes it highly valuable for renewable energy grids.

#### Key Observations

1. **Design Challenges:** The system operates under high pressure and large water flows, requiring robust materials and precise engineering.
2. **Energy Imbalance:** The weekly energy requirement for pumping (12.41 MUs) exceeds the energy generated (9.57 MUs), but this is typical for pumped storage systems.
3. **Dual Role Efficiency:** The system seamlessly switches between motor and generator modes, emphasizing its versatility.

## V. CONCLUSION:

Operating since 2008, the facility is essential in balancing the local energy demand and supply. Having 3.21 million cubic meters of reservoir capacity, it can effectively store large amounts of water, therefore facilitating effective production and storage of energy. The plant guarantees great efficiency in both its pumping and generating modes by using a net head of 400 meters, thereby maximizing the energy conversion mechanism. The plant produces 1.5 million units (MUs) of daily power, which greatly helps the system during peak demand. This amounts to 469.5 gigawatt-hours (GWh) of power annually, which highlights its significant part in meeting local energy demand. The operational plan is meant to optimize effectiveness and satisfy different energy consumption. Except on Sundays, when the plant is set aside for maintenance or other operational needs, it provides electricity for six hours everyday during peak demand. Operating in seven hours daily in pumping mode, the plant stores potential energy by pushing water back into the reservoir during off-peak hours. This procedure guarantees the availability of stored energy for generating during peak demand as well as helps the stability of the grid by using surplus power during low-demand times. The plant's dual-mode capability best illustrates the features of pumped storage technology in contemporary energy networks. Through effective control of energy storage and production, the facility helps to integrate renewable energy sources, lower dependency on fossil fuels, and preserve grid stability. Finally, this plant is evidence of outstanding hydropower engineering and constantly supports the energy infrastructure. Support of regional and national energy objectives depends on its operational efficiency, strong design, and smart use of natural resources, which define sustainable energy management.

## REFERENCES

- [1] Liang Wang, Xiaoyan Han, Gang Chen, Lijie Ding, Shumin Miao, Hua Zhang, Xiaoqing Chang, Bin Luo, "Research & Prospect of Cascade Hydro-Photovoltaic pumped storage Hybrid power Generation Technology," IEEE PES Innovative Smart Grid Technologies Asia, 978-1-7281-3520-5/19/2019.
- [2] Emilia Nobile, Gökhan Sari and Alexander Schwery, "Variable Speed Hydro Pumped Storage as Flexible Enabler of Intermittent Renewable Penetration", 978-1-5386-7703 2/18, 2018 IEEE.
- [3] Dimo Stoilov, Georgi Stoilov and Sylvia Goranova, "Water Storage Electric Power Plant with Controllable Suction Head," 2021 17-th International Conference on Electrical Machines, Drives and Power Systems (ELMA), 1-4 July 2021, Sofia, Bulgaria.
- [4] Shuai Zhang , Yue Xiang , Junyong Liu, Jichun Liu, Jingxian Yang , Xu Zhao , Shafqat Jawad , and Jing Wang, "A Regulating Capacity Determination Method for Pumped Storage Hydropower to Restrain PV Generation Fluctuations," CSEE JOURNAL OF POWER AND ENERGY SYSTEMS, VOL. 8, NO. 1, JANUARY 2022.
- [5] Kazuyuki NAKAMURA , Takashi SHIGENOBU, Sho HARADA, Takaaki MURAKI, "A High Head Pumped Storage Power Plant Rehabilitation Project," International Conference on Renewable Energy Research and Applications, 10.1109/ICRERA.2012.6477312 , IEEE , November 2012.
- [6] Sohrab Mirsaedi, Majid Gandomkar, Mohammad Reza Miveh, Mohammad Reza Gharibdoost, "Power System Load Regulation by Pumped Storage Power Plants," Proceedings of 17th Conference on Electrical Power Distribution, IEEE 2012.