Pumped Storage Hydropower Systems Training Course

Professional Development Training Course Outline

Category	Renewable Energy	**Duration**	5 Days
Base Fee	$1,500 USD	**Delivery Mode**	Online / On-site Hybrid

Course Introduction

Pumped Storage Hydropower (PSH) is emerging as a critical long-duration energy storage, grid flexibility, and renewable energy integration technology as power systems accommodate rapidly increasing shares of variable solar and wind generation. In 2025, global pumped-storage capacity surpassed 200 GW, with 11.7 GW added during the year and a further 243 GW under construction, highlighting the technology's expanding role in energy security, grid resilience, decarbonization, and renewable-energy balancing. Pumped Storage Hydropower Systems Training Course develops practical knowledge of PSH planning, design, hydraulic systems, reversible pump-turbines, electrical infrastructure, reservoir management, grid services, environmental considerations, project economics, and modern digital optimization.

The course connects hydropower engineering with the latest energy-transition, smart-grid, flexibility, and energy-storage priorities. Participants explore how PSH can provide peak shifting, frequency regulation, voltage support, operating reserves, inertia, renewable firming, congestion management, and long-duration storage while examining real-world project case studies and emerging hybrid configurations. The curriculum is particularly relevant as electricity systems face rising demand from electrification, industry, EVs, and data centres and require greater flexibility to integrate renewable generation securely and cost-effectively.

Programme Curriculum

Pumped Storage Hydropower Systems Training Course

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Course Duration

5 days

Course Objectives

By the end of the course, participants will be able to:

1. Explain the fundamentals, operating principles, and value proposition of Pumped Storage Hydropower.
2. Evaluate PSH as a long-duration energy storage (LDES) solution for modern power systems.
3. Assess site selection, topography, geology, hydrology, and reservoir configuration for PSH projects.
4. Understand pump-turbine, motor-generator, hydraulic, mechanical, and electrical system design.
5. Analyze grid flexibility, renewable-energy integration, peak shaving, and energy arbitrage opportunities.
6. Apply principles of frequency regulation, voltage support, inertia, reserves, and ancillary services.
7. Evaluate fixed-speed and variable-speed PSH technologies and their operational advantages.
8. Develop an understanding of hydraulic transients, water conveyance, cavitation, and surge-control considerations.
9. Assess reservoir management, water availability, environmental flows, sustainability, and climate resilience.
10. Examine digitalization, predictive analytics, AI-assisted optimization, and smart-grid integration for PSH operations.
11. Evaluate technical feasibility, CAPEX/OPEX, lifecycle economics, revenue stacking, and project bankability.
12. Understand risk management, permitting, environmental and social considerations, and project delivery.
13. Apply industry knowledge through real-world case studies, scenario analysis, operational simulations, and project-development exercises.

Target Audience

1. Hydropower engineers and renewable-energy engineers
2. Power-system planners and grid operators
3. Energy-storage professionals and utility specialists
4. Project developers, EPC professionals, and consultants
5. Electrical, mechanical, civil, and hydraulic engineers
6. Energy policymakers, regulators, and government officials
7. Asset managers, investment professionals, and infrastructure financiers
8. Researchers, academics, sustainability professionals, and technical managers

Course Modules

Module 1: Pumped Storage Hydropower Fundamentals and Energy-Transition Role

- PSH operating principles:
- Open-loop, closed-loop, and hybrid **pumped-storage configurations**.
- PSH versus batteries and other **energy-storage technologies**.
- Role of PSH in **renewable integration, grid resilience, and energy security**.
- **Case Study:** Global PSH expansion and the transition toward the “water battery” concept, with global capacity exceeding 200 GW.

Module 2: Site Selection, Hydrology, Geology, and Reservoir Engineering

- **Site screening and feasibility assessment** using elevation, head, geology, hydrology, and infrastructure criteria.
- Upper and lower reservoir configurations and **closed-loop site development**.
- Water availability, evaporation, inflows, sedimentation, and **climate-resilience assessment**.
- Geological investigations, tunnelling conditions, foundations, and geotechnical risk.
- **Case Study:** Comparative evaluation of potential PSH sites using technical, environmental, and grid-access criteria.

Module 3: Hydraulic Systems, Pump-Turbines, and Mechanical Equipment

- Reversible **Francis pump-turbine** technology and operating modes.
- Hydraulic waterways: **intakes, penstocks, tunnels, surge tanks, and tailraces**.
- Pumping and generating cycles, efficiency, head, flow, and power relationships.
- **Variable-speed technology**, hydraulic performance, cavitation, and transient behavior.
- **Case Study:** Variable-speed PSH applications for improved operating flexibility and faster grid response.

Module 4: Electrical Systems, Grid Integration, and Ancillary Services

- Motor-generators, transformers, switchyards, protection, and **high-voltage grid connection**.
- Frequency response, voltage control, **reactive power**, inertia, and operating reserves.
- Renewable-energy balancing and **solar/wind firming**.
- Black-start capability, grid restoration, and **system resilience**.
- **Case Study:** PSH as a provider of grid reliability and ancillary services, including frequency and voltage support.

Module 5: PSH Operations, Dispatch, Optimization, and Digitalization

- Day-ahead and real-time **PSH dispatch optimization**.
- Energy arbitrage, peak shifting, renewable curtailment reduction, and **revenue stacking**.
- Multi-timescale scheduling and coordination with wind and solar.
- **AI, predictive analytics, digital twins, forecasting, and smart-grid controls**.
- **Case Study:** Multi-timescale pumped-storage optimization demonstrating reductions in residual-load fluctuation and renewable curtailment.

Module 6: Project Economics, Financing, Markets, and Commercial Models

- **CAPEX, OPEX, lifecycle cost, efficiency, availability, and asset-life analysis**.
- Revenue streams from energy arbitrage, capacity, ancillary services, and **grid-flexibility markets**.
- Financial modelling, sensitivity analysis, risk allocation, and **bankability**.
- Long-term contracting, policy incentives, market design, and investment considerations.

- **Case Study:** PSH optimization and market participation, including research showing potential economic gains from improved dispatch strategies.

Module 7: Environmental, Social, Sustainability, and Risk Management

- Environmental impact assessment and **sustainable hydropower** principles.
- Aquatic ecosystems, biodiversity, water management, and environmental-flow considerations.
- Community engagement, land use, social impact, and stakeholder management.
- Climate risks, extreme events, dam safety, emergency planning, and **resilience engineering**.
- **Case Study:** Emerging approaches that combine hydropower flexibility with ecological-flow management to support renewable integration.

Module 8: Future PSH Technologies, Hybrid Systems, and Strategic Project Development

- Hybrid PSH with **solar PV, wind, batteries, and conventional hydropower**.
- Advanced variable-speed systems and next-generation **grid-forming and flexibility services**.
- Retrofitting existing hydropower infrastructure with pumping capability.
- Project development roadmap
- **Case Study:** Cascade hybrid pumped-storage development using retrofitted pumping stations to improve seasonal storage and renewable-energy integration.

Training Methodology

- Interactive lectures and presentations.
- Group discussions and brainstorming sessions.
- Hands-on exercises using real-world datasets.
- Role-playing and scenario-based simulations.
- Analysis of case studies to bridge theory and practice.
- Peer-to-peer learning and networking.
- Expert-led Q&A sessions.
- Continuous feedback and personalized guidance.

Register as a group from 3 participants for a Discount

Send us an email: info@fineskilltrainingcenter.org or call *+254769199797*

Certification

Upon successful completion of this training, participants will be issued with a globally- recognized certificate.

Tailor-Made Course

We also offer tailor-made courses based on your needs.

Key Notes

a. The participant must be conversant with English.

b. Upon completion of training the participant will be issued with an Authorized Training Certificate

c. Course duration is flexible and the contents can be modified to fit any number of days.

d. The course fee includes facilitation training materials, 2 coffee breaks, buffet lunch and A Certificate upon successful completion of Training.

e. One-year post-training support Consultation and Coaching provided after the course.

f. Payment should be done at least a week before commence of the training, to Fineskill Training Center account, as indicated in the invoice so as to enable us prepare better for you.

Upcoming Scheduled Sessions

Start Date	End Date	Location	Price
21 Sep 2026	25 Sep 2026	Online	$1,000
21 Sep 2026	25 Sep 2026	Physical	$1,500
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0
21 Sep 2026	25 Sep 2026	Physical	$0

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