# Low-Head Hydropower Development at Coon Rapids Dam

Semester: Spring 2026

Nathaniel Holguin  , Karsten Jones  , Anthony Nuzzo  , Dawson Stevens 

Steve Sanghi College of Engineering, Northern Arizona University, Flagstaff, AZ 86011

## Abstract

The United States contains over 80,000 non-powered dams, many of which are low-head structures that do not generate electricity, representing a significant opportunity for renewable energy using existing infrastructure. This project evaluates the feasibility of retrofitting Coon Rapids Dam with a low-head hydropower system capable of operating under variable river flow conditions while maintaining dam functionality and public safety. A modular turbine system was designed using flow duration data and computational modeling to optimize performance. The final design achieves a nameplate capacity of **2.17 MW** and generates approximately **12,699 MWh** annually, with an estimated levelized cost of energy of **$79.61/MWh**. Experimental validation was conducted using a laboratory-scale turbine and Prony brake dynamometer. These results demonstrate that retrofitting existing low-head dams is a cost-effective and scalable solution for renewable energy generation.

## Requirements

**Siting & Design**
Retrofit a non-powered dam into a feasible hydropower system

**Energy Output**
Target 1–10 MW under variable flow conditions

**Economic Feasibility**
Achieve competitive LCOE and lifecycle cost performance

**Environmental Impact**
Minimize ecological disruption and maintain river compatibility

**Structural Compatibility**
Integrate with existing infrastructure without major modification

**Grid Integration**
Deliver reliable electrical output within transmission constraints

**Community Impact**
Provide local renewable energy and sustainability benefits

## Site Selection Methods

- Evaluated using 8 criteria
- Utilized resources from Oakridge National Library[2]
- Evaluated for low head, high flow, run of river style dams to fit Voith StreamDiver needs

**Table 1. Site Selection Decision Matrix for Top 3 Sites**

| Criterion | Weight | Fish Barrier CA00034 | | Coon Rapids Dam MN00507 | | John C. Stennis MS03056 | |
|---|---|---|---|---|---|---|---|
| | | Score out of 100 | Weighted Score | Score out of 100 | Weighted Score | Score out of 100 | Weighted Score |
| Estimated Mean Output | 25% | 22.68 | 5.67 | 100 | 25.00 | 100.00 | 25.00 |
| Flow Rate Consistency (1-CV) | 7.50% | 50.55 | 3.79 | 50.80 | 3.81 | 38.26 | 2.87 |
| Head Consistency (1-CV) | 7.50% | 92.17 | 6.91 | 87.43 | 6.56 | 38.26 | 2.87 |
| Poximity to Infrastructure | 12% | 95.00 | 11.40 | 100.00 | 12.00 | 90.00 | 10.80 |
| Ownership and Regulation | 12% | 60.00 | 7.20 | 70.00 | 8.40 | 80.00 | 9.60 |
| Structure | 12% | 60.00 | 7.20 | 90.00 | 10.80 | 70.00 | 8.40 |
| Risk | 12% | 100.00 | 12.00 | 67.00 | 8.04 | 67.00 | 8.04 |
| Local Need | 12% | 99.00 | 11.88 | 28.00 | 3.36 | 28.00 | 3.36 |
| Total | 100% | | 66.05 | | 77.97 | | 70.94 |
| Rank | | 2 | | 1 | | 3 | |

## Design and Operations

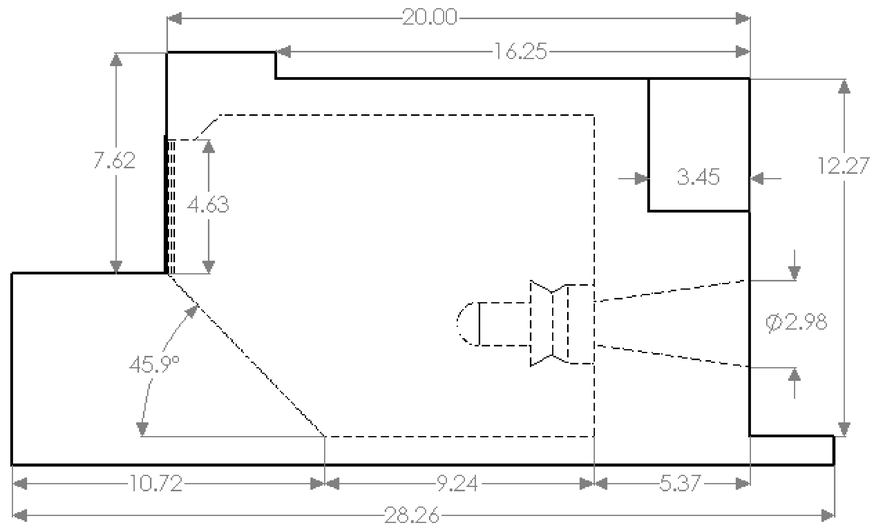


Figure 1: Turbine Housing Cross-Section, based off StreamDiver unit layout [1]

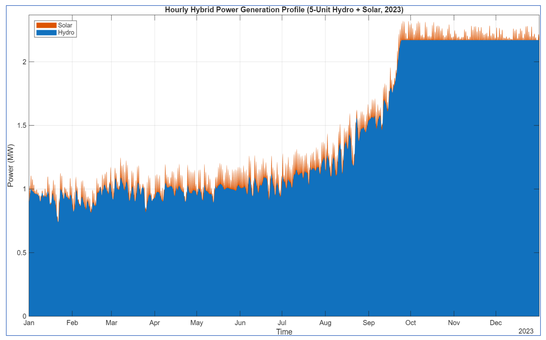


Figure 2. Hybrid System Generation

| Overall Power Generation | | | |
|---|---|---|---|
| | Hydro | Solar | Overall |
| Generation (MWh) | 12700 | 415 | 13115 |
| Average Output(MW) | 1.45 | 0.047 | 1.50 |
| Capacity Factor | 67% | 15.50% | 61.90% |
| LCOE ¢/kWh | 5.77 | 12.16 | 5.97 |

Table 2. Overall Power Generation

## Project Results &

- **Objective:** Evaluate the feasibility of retrofitting a hydropower system at Coon Rapids Dam
- **Design Outcome:** A **5-unit turbine configuration** was selected to balance efficiency, cost, and flow variability **while maximizing energy capture under low-head conditions**
- **Performance:**
  → **2.17 MW** installed capacity
  → **12,699 MWh/year** energy generation
  → **67% capacity factor** under variable flow conditions
- **Economic Feasibility:**
  → **LCOE: $79.61/MWh** *(competitive with utility-scale renewables)*
- **Impact:**
  → **Demonstrates that non-powered dams can be converted into economically viable renewable energy systems** with minimal infrastructure modification

Table 3. Selected Configuration of 5 Turbine Units

| Units | Capacity (MW) | Energy (MWh/yr) | CF | LCOE ($/MWh) |
|---|---|---|---|---|
| 5 | 2.17 | 12,699 | 67% | $79.61 |

The selected design balances energy production and cost efficiency under variable flow conditions.

## References

[1] Voith GmbH & Co. KGaA, "Streamdiver | Voith," *Voith GmbH & Co. KGaA.* [Online]. Available: https://www.voith.com/corp-en/hydropower-components/streamdiver.html. [Accessed Mar. 29, 2026].
[2] Carly H. Hansen, Juan Gallego Calderon, Camilo Bastidas Pacheco, Cleve Davis, Rohit Mendadhala and Glenn Russell. 2024. Technical Potential for Hydropower Capacity at Non-powered Dams. HydroSource. Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA. DOI: 10.21951/HydroCapacity_NPD/2570407

## Acknowledgements

Albin Atzmueller – Small Hydro Concept Specialist, Voith Group
- Provided guidance on StreamDiver implementation

Tim Chambers – Coon Rapids Dam Operator, Three Rivers Park
- Provided site-specific insight on dam operations

Carson Pete – Mechanical Engineering Professor, Northern Arizona University
- Capstone Advisor

Mark Christian – Technical Leader: Hydropower Modernization, EPRI
- HCC Industry Mentor