Peninsular Paper Dam
Hydropower Generating Capacity Estimate

Huron River Watershed Council

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Disclaimer

This document should not be used in place of a professional hydroelectric feasibility and cost assessment conducted by professional engineers. This document is only intended to 1) provide an estimate of the hydroelectric-generating capacity of Peninsular Paper Dam based on its location and dimensions, and 2) discuss additional considerations common to enabling hydropower at dams of similar scale. The information provided is based on publicly available resources. Many unique and often unforeseen challenges can tremendously affect the feasibility and total cost of enabling hydropower at any dam. This document is only intended to help inform the City of Ypsilanti and its residents as they consider options for repair or removal of Peninsular Paper Dam. HRWC has provided the information below based on the best available data and references, but the estimates provided should be not considered as formal conditions of replacing or removing infrastructure.

Background

During the Ypsilanti City Council Meeting on December 4th, 2018, the Sustainability Commission Meeting on January 14, 2019, and in discussions with city councilmembers, many community leaders expressed interest in the feasibility of rebuilding the hydroelectric generating capability at Peninsular Paper Dam (Pen Dam).

Based on that interest, HRWC has reviewed existing information relevant to hydropower capacity at Pen Dam. The installation of turbines, the construction of transmission infrastructure, operating costs, maintenance in addition to the $807,000 estimated for repairing the dam, FERC licensing, and other associated safety costs are not considered in detail here. This document only examines the possible hydropower capacity of Pen Dam based on its location on the river and its dimensions. There are many other potentially limiting factors that are not discussed here.

Estimating Hydropower Capacity

The capacity for power generation of a dam can be estimated using the following the equation:

$$P = (f) \times (g) \times (Hnet) \times (n)$$

P is the estimated capacity of power output based on dam dimensions, location on the river, average annual flow rate, and standard efficiency losses power, measured in kilowatts (kW).

(f) is the flow rate in cubic meters /second (m^3/s) or cubic feet per second (cfs).

(g) is the gravitational constant, 9.8 m/s^2

(Hnet) is the net head.[1] This is the gross head physically measured at the site, less any head losses. For Pen Dam this can be estimated to be the head of 14 ft minus a standard assumed 10% hydraulic (spillover) loss, making the net head 12.6 feet, or 3.8 meters.

(n) is the product of all of the component efficiencies, which are normally the turbine, drive system and generator. Loss of efficiencies are multiplicative. For typical small hydro systems the turbine efficiency would be 85%, drive efficiency 95% and generator efficiency 93%, so an approximate overall system efficiency would be: 0.85 x 0.95 x 0.93 = 0.751 (75%).

HRWC estimated the flow at Pen Dam by using the high quality USGS gage record at Wall Street in Ann Arbor. This record includes data over more than 30 years and provides an accurate average over high and low flow years.

The 30-year annual average flow at Wall Street is 524 cubic feet per second (cfs). Geddes Dam (also called Dixboro Dam) is only a bit downstream, with 31 square miles of extra drainage to the river. That results in an estimated average flow of 546 cfs at Geddes. An additional 41 square miles drain to the river above Pen Dam, resulting in an annual average flow of 575 cfs. We used the same method to estimate the flow at Argo and Superior Dams.

A 2010 study[i] commissioned by the Army Corps of Engineers (ACoE) that examined Argo and Geddes dams in Ann Arbor referenced data from the Michigan Department of Environmental Quality and USGS also used in a prior 2008 study conducted by Stantec Consulting.[ii] ACoE estimated flow at Geddes to be 633 cfs and 536 at Argo, higher than what we estimate. Annual flow variability on the Huron River is high. The standard deviation in flow is 113 cfs. The ACoE study used USGS data over a shorter reference period that tended to be higher than the long-term average. The flow values we estimate are therefore lower along the entire section of river considered. As a result, we estimate Geddes and Argo dams would also have a lower hydropower potential than reported in the ACoE study.

By converting to metric units, using the above estimated values of flow and following the method above, we estimate the hydropower capacity at Pen Dam in kilowatts to be P = 16.28 m^3/s x 9.8 m/s^2 x 3.8 m x 0.75 = 455 kW. We have assumed a water density of 1000 kg/m^3.

For comparison, we have similarly estimated the flow at Geddes, Argo, and Superior dams to be 546 cfs (15.5 m^3/s), 522 cfs (14.8 m^3/s), and 571 cfs (16.3 m^3/s) respectively. The resulting hydropower capacities at each dam location are provided in the table below.

Dam	Flow (m^3/s)	Head, net effective (m)	Capacity (kW)
Argo	14.8	3.4	370
Geddes	15.5	4.9	557
Superior	16.2	6.9	822
Pen	**16.3**	**3.8**	**455**

The above table shows the estimated flow at each dam based on a 30-year average of flow at the Wall Street USGS gage in Ann Arbor, the net effective head of each dam, and the calculated hydroelectric capacity. The exact values depend on assumptions in the method of estimation. The above table should only be used for informative estimates and to compare relative flow and capacity between dams.

[1] Head is the vertical change in elevation between the reservoir water level and the downstream water level.

These values should be interpreted as a practical estimate of the long-term ceiling for hydroelectric generation. Many other factors can significantly reduce actual electrical output at any location.

Pen Dam's capacity is between that of Argo and Geddes. This is expected as Pen Dam has more river above it and a resulting higher flow. It is a larger dam than Argo with higher head but has a lower head than Geddes. Pen Dam experiences similar flow to Superior Dam but is much shorter and therefore has much less capacity Superior Dam.

We have used a slightly different methodology for estimating output than what the ACoE used. ACoE included the inefficiencies throughout specific elements of their analysis, while we have assumed a generic, standard level of efficiency that we have applied to all dams. In reality, energy production efficiencies vary between dams. To make sure our method yields similar results under similar conditions, we repeated our estimation using the high ACoE flow values. In that case, our flow values for Geddes and Argo are consistent with what the ACoE reported in 2010. The estimate of total output depends on the efficiency method used, but for estimating the relative differences in capacity between the dams being considered, the magnitude of flow at each dam location is more relevant than the method used to estimate efficiency.

We estimate the maximum electricity generation per year at Pen Dam to be about 3,400,000 kWh, assuming a maintenance downtime of 15%. According to a 2008 study of Ann Arbor's dams,[iii] Barton and Superior Dams in Ann Arbor, which currently produce hydroelectricity, experience 13% and 19% maintenance downtime, respectively.

The actual electricity utilized by Barton and Superior Dams on average was reported in the 2008 Stantec study to be 54% and 46% respectively. Estimating 50% for Pen Dam, the expected annual average utilized electricity would be about 1,993,000 kWh. This total would place Pen Dam between Argo and Geddes in terms of expected utilized electricity.

Summary of the 2010 Geddes and Argo Report

The ACoE study ranked the favorability of Geddes and Argo dams in seven critical criteria for the long-term feasibility and cost-effectiveness of hydroelectric power. They found Geddes Dam was favorable in 3 of the 7 criteria. Argo was found favorable in none of the criteria. Overall, Geddes was found to be more preferable but not cost-effective. Argo was found to be less preferable and less cost-effective. (The benefit-to-cost ratio in both cases was below 1.0).

The study investigated the costs associated with three options for power delivery to the grid and two options for generating power at Argo Dam. Depending on the option considered, the total estimated cost of enabling hydropower ranged from 4.4 to 9.3 million.

Superior Dam

The City of Ann Arbor currently generates hydroelectricity from Superior Dam, immediately up river of Pen Dam. In terms of hydrologic position on the river, Superior Dam is the closest to Pen Dam. Superior Dam (25-foot head) is approximately twice as high as Pen Dam on a narrower section of river and therefore has approximately twice the electric-generating potential.

Superior Dam, however, currently does not generate enough electricity to cover its own annual maintenance and operating costs. Ann Arbor is currently in the early phases of understanding the feasibility of removal of Superior Dam.

Implications for Pen Dam

Without a thorough assessment, there is much uncertainty about which specific elements of the Argo and Geddes study are relevant to Pen Dam. Pen Dam is currently in poorer condition than Argo or Geddes were in 2010 when the study took place. Argo and Geddes are newer dams with greater capacity for reconstruction or additional new infrastructure. Many of the steps needed to enable hydropower at Argo and Geddes, if implemented similarly at Pen Dam, would require additional costs beyond the estimated cost of repairing Pen Dam.

Comparing the potential hydropower capacity of the three dams based on their location and design is more straightforward. The electricity-generating potential at Pen Dam would be less than that of Geddes which was not found to be cost-effective, and significantly less than Superior Dam, which is currently generating hydroelectricity but is not fiscally sustainable.

Other Considerations

In addition to the limitations of generating hydropower based on dam size and available flow, many unrelated issues commonly affect the feasibility of enabling hydropower at a dam. The following issues are apparent in the previous studies of Ann Arbor's dams and in other feasibility studies from dams across Michigan.

Federal Energy Regulatory Commission (FERC) Licensing

The FERC licensing process has presented an obstacle for numerous hydropower projects in Michigan. A 2009 assessment of the Boardman River near Traverse City, Michigan estimated that FERC licensing alone would cost $600,000-850,000, based on a review of contemporary hydropower projects pursued by utilities and communities across Michigan.[iv]

The 2008 study of Ann Arbor's Barton and Superior dams included an allowance of $300,000 for the initial FERC licensing process, but noted that the cost was highly dependent on the number of environmental impact studies needed. The study also points out that additional initial and annually recurring costs should be expected. In the case of Barton and Superior Dams, the annual costs were estimated at $110,000 per site.

Transmission Infrastructure and Supporting Equipment

Sites without transmission infrastructure that would need to have it installed frequently encounter additional costs that substantially increase the total cost of enabling hydropower. Pen Dam was never constructed to provide electricity to the grid, so there is little supporting infrastructure currently available near the site. Virtually all transmission infrastructure would need to be built.

Another critical assumption regarding power generation is that the dam can house a turbine system capable of capturing all of the available flow minus efficiency and hydraulic (spillover) losses. That is often not the case. It's possible the dam would need to be significantly retrofitted or partially rebuilt to

capture and transmit all of the available capacity. That would greatly increase the cost of enabling hydropower.

Increased Safety Concerns and Safeguard Requirements

Enabling hydropower increases the number of public safety hazards at the site. In many cases, this requires additional area and fencing. The other currently operational hydroelectric dams along the Huron River exhibit these requirements.

Additional Maintenance and Staffing Commitments

Enabling hydropower requires around-the-clock operator attention, either with staff operators on-site or on-call. Maintenance costs and staffing needs vary with the construction of the hydroelectric plant.

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[i] Argo and Geddes Dams Hydropower Study Final Report. Presented to U.S Army Corps of Engineers by VECSIE Joint Venture. VA Ann Arbor Healthcare System, Ann Arbor, Michigan

[ii] Hydroelectric Redevelopment: Argo and Geddes Dams Feasibility Study. 2008. Stantec Consulting Michigan Inc. Ann Arbor, Michigan.

[iii] Hydroelectric Redevelopment: Argo and Geddes Dams Feasibility Study. 2008. Stantec Consulting Michigan Inc. Ann Arbor, Michigan.

[iv] Summary of Hydroelectric Power Generation at the Boardman Dams. 2009. Environmental Consulting and Technology Services, Traverse City, Michigan.