Hydroelectric Power in Michigan

The Consumers Energy Story

AND

The Lyons Connection

Consumers - Historic Markers

"Flowing water has long provided power to mines and mills. With advances in electricity in the 1800s, waterpower was soon used to generate electricity. The first public demonstration of hydroelectric power in the country occurred on July 24, 1880, when sixteen carbon arc street lamps lit up Grand Rapids using a belt driven dynamo (generator) powered by a water turbine at the Wolverine Chair Factory. Michigan's extensive water resources were harnessed to power electric generating equipment first at existing dams and mills and later at sites built expressly for hydroelectric generation. The electricity from these plants provided power to homes and businesses and helped fuel Michigan's growth as one of the nation's premier industrial states."

A Foote Hold

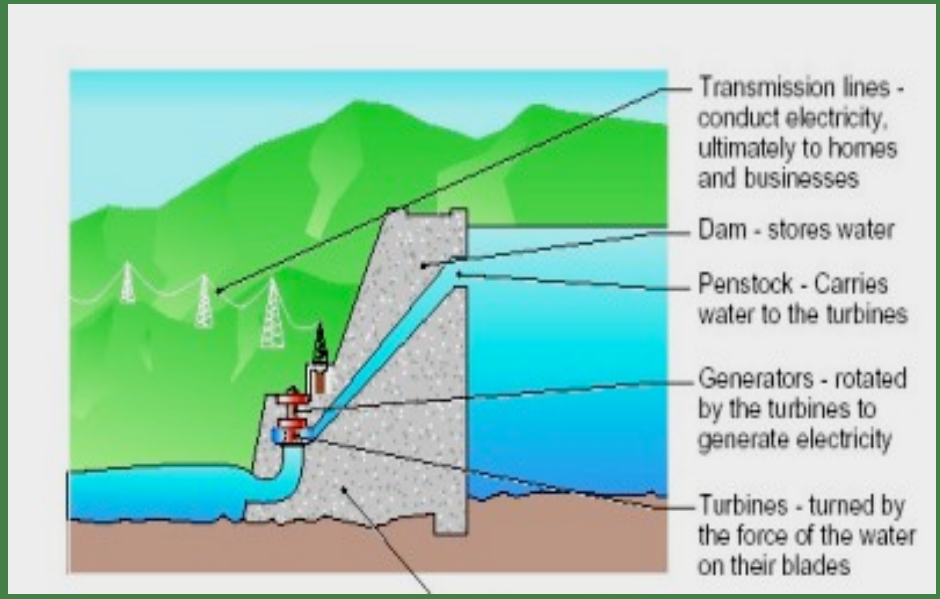
- William A Foote and James B Foote were brothers who were raised in Adrian
- Originally WA was in the grist mill business in Adrian, when at the age of 30 in 1884
  - He rented space on his water powered mill wheel to Thomson - Houston one of many fledgling electricity startups
  - The space was for a belt to run a generator to power 12 street lights in downtown Adrian – he was fascinated with the potential
  - Within a year WA Foote abandoned the grist mill business, recruited his 17 year old brother JB to join him and started what would become today's Consumers Energy

A Foote Hold

- After selling his Adrian enterprise, Foote moved to Jackson where he established the Jackson Electrical Light Works in 1886 – the first to light downtown Jackson electrically
  - Similar enterprises followed in Battle Creek and Adrian within a few years and the Footes were on their way
  - River power already created by dams built for grist mills, sawmills and the like were the logical location to install the electrical generators and unlike coal that had to be bought and shipped in, the water was “free”

Falling Water

- Hydroelectric production followed the same principals as earlier hydro mechanical uses had
  - The potential energy of falling water is used to turn turbines instead of grinding wheels and similar devices
  - Then the turbine spins a generator to make electricity



However, while the adaptation of using water powered turbines to turn generators was quickly adapted, controlling and transmitting the electricity was not, and so these first electric enterprises are confined to locations in existing towns.

River Power

Trowbridge Dam on the Kalamazoo River – circa 1899, shortly after it went into production. Trowbridge operated until 1965. Today a part of the dam remains.

- In 1898 the Footes sought to build a dam on the Kalamazoo River and transmit the power an unheard of 24 miles to the City of Kalamazoo
  - Trowbridge Dam - 22 foot high, was Michigan's first "big" earthmoving project
  - Inventing insulators and transmission equipment as they went, the made the venture a success

Michigan's Hydro Power Era

- With the success of the Footes' Trowbridge transmission gamble and similar efforts underway elsewhere, Michigan's hydro dam building era was off and running
  - Virtually every significant dam construction or reconstruction in Michigan would take place between 1900 – 1930
- New uses for electricity were being invented almost daily and power demands, both in the workplace and the home, would soon explode
- Public uses, particularly lighting and electric rail car were the first significant uses, but the latter would be short lived with the advent of the automobile

Powering Up Grand Rapids

Webber Dam – Grand River, In operation 1907

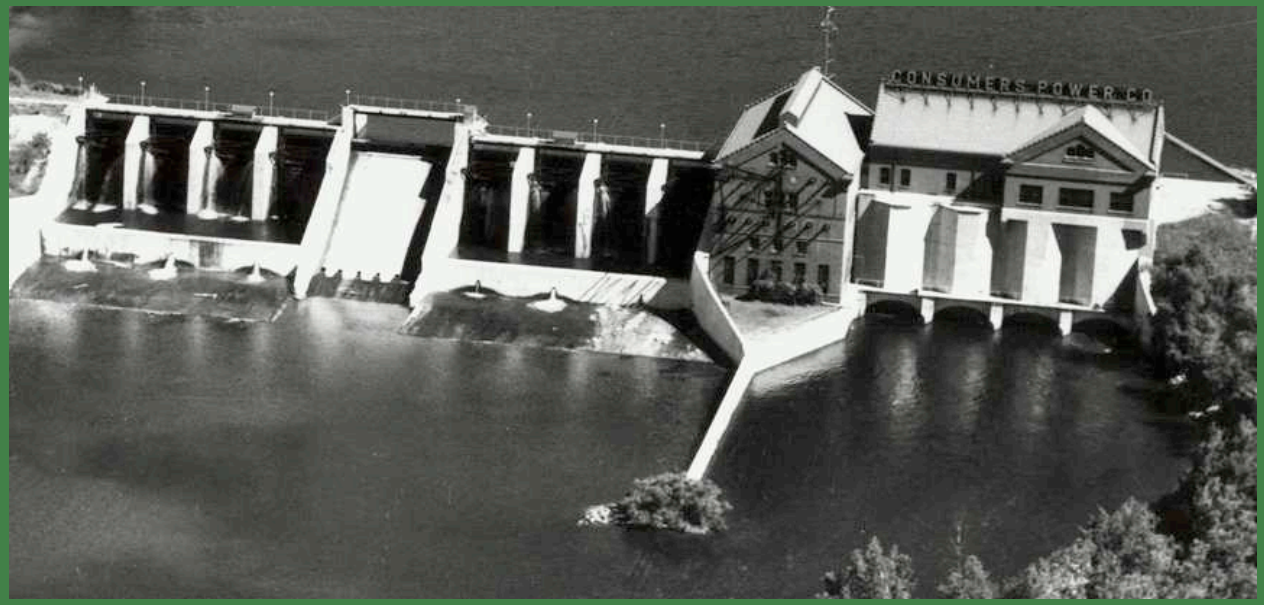
Rogers Dam – Muskegon River, In operation 1906

Croton Dam – Muskegon River, In operation 1907.

The 100,000 volt power line that led from Croton to Grand Rapids was the highest voltage in the world at that time.

Consumers Power

- By 1910, the Foote Brothers had consolidated the many companies created to embark on various projects into Consumers Power
- By 1915 when WA Foote died suddenly, the center of corporate power had already shifted to Wall Street and a multi-state conglomerate was forming



Rapid Development

- Between 1906 and 1917, nine major dams that Consumers still operates today were built
- Construction slowed to a crawl when the country become embroiled in World War I

Tippy Dam on the Manistee River about 10 miles east of Manistee

Laying Claim

- When the Footes began the Trowbridge Dam project in 1898, they had hooked up with a Jackson based civil engineer named William G Fargo
  - The association would last throughout both their careers
- As the competition for power sites and service territories quickly heated up, Fargo began a project in 1911 to survey 70 ± rivers and streams in Michigan for existing and potential hydropower sites
- In his 1913 comprehensive report, Fargo notes that the Grand River is the most developed in Michigan
  - He catalogs 19 existing dam sites with hydro mechanical and / or hydropower developments

Lyons Dam – Built 1857

- Fargo reports in 1913 that the dam has:
  - A 9.3 foot head with a 279 foot long spillway made of wood, filled with stone and capped with concrete
    - He notes that it leaks some, but is in fair condition
  - There is a 990 foot long headrace leading to the three current power users
    - Jonathan Hale and Sons have two turbines installed to power their flour mill – they own 17½/34^{ths} of the water rights at the site
    - The Village of Lyons municipal plant owns 13½/ 34^{ths} of the water rights and also has two turbines generating electricity for the village
    - The F H Beach Handle & Ball Club plant owns the remaining 3/ 34^{ths} for a “small vertical wheel.” Fargo says this plant is of little value and the wheel is worthless

Lyons Dam

- In 1915 Consumers bought out the J Hale and F Beach interests
  - This gave them a majority 20½/34^{ths} of the water rights at the site
- It is likely they intended to rebuild the dam and a new power plant at that time, but World War I brought many such projects to a hault

Lyons Dam Fails

- Records are not precise, but sometime between Fargo's 1913 description and these June 22, 1919 photographs, the Lyons dam washed out
  - Remember Fargo had said it was a tad leaky in 1913

The New Lyons Dam

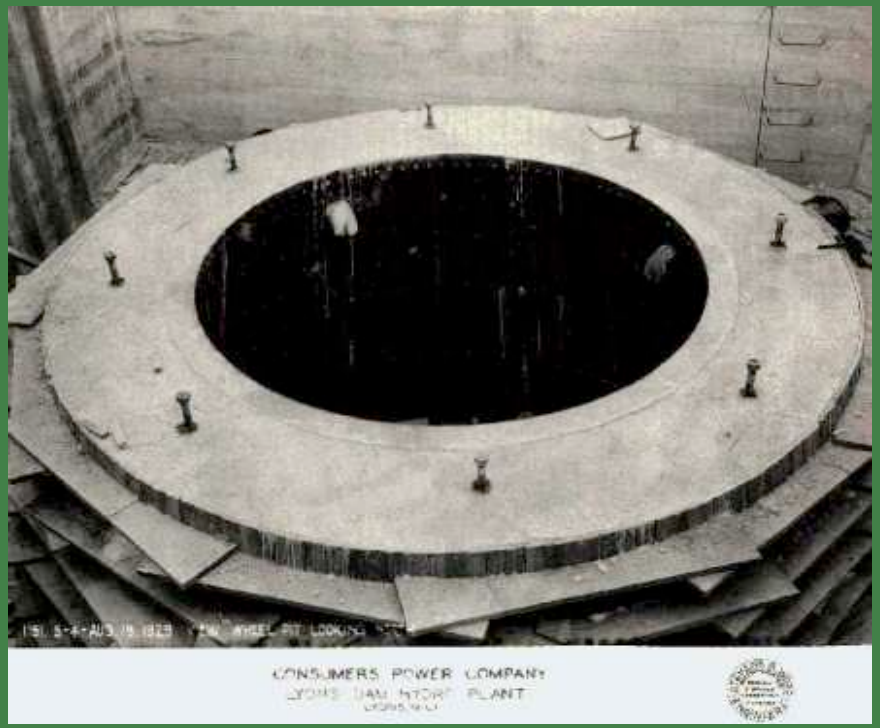
- In the early 1920s after the war, the money again began to flow and the early Consumers Power was now part of a much larger multi-state corporate trust
- They went on an active campaign to buy out competitors and obtain power production rights and service territories all over Michigan
- Projects that had been put on hold during the war were also resurrected and among those was reconstruction of the Lyons Dam in 1929

The New Lyons Hydro

Construction photos dated August 19, 1929

Stevens & Wood Engineering Inc.

Power plant under construction



Turbine Pit

The End of the Dam Building

- Consumers built three dams that we still operate during the 1920s and early 30s
- With the completion of these projects, Consumers' and Michigan's dam building era came to an end
- The "good" dam sites were largely gone and power generation began to shift to large coal plants

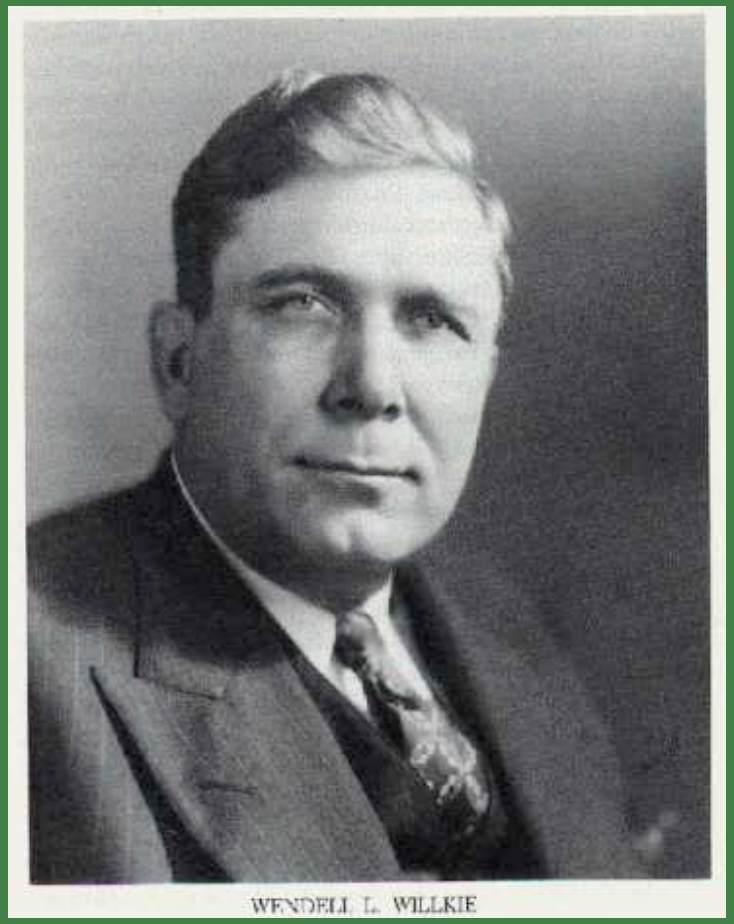
Hardy Dam, completed in 1931 on the Muskegon River in Newaygo County is Michigan's biggest dam at 100 feet high and 30,000 kW of production capacity

Commonwealth & Southern

The far-flung domain of Commonwealth & Southern before the forced sale in 1939 of its Tennessee properties to the Tennessee Valley Authority.

- Consumers Power had become part of a large multi state Wall Street holding company named Commonwealth & Southern
- It was the country's largest utility conglomerate with power companies that covered parts of 10 states

Commonwealth & Southern


WENDELL L. WILLKIE

- In 1933, just a few years after he had moved from Akron, Ohio to New York to become an Attorney at C&S, 41 year old Wendell Willkie became president of the company
- Over the next 10 years he would play an important role on a national stage

Changing Rural America

- Much of rural America's power usage at this time was limited to lighting
- Under Willkie's leadership electric rates were cut by nearly one-third
- He planned to make up the lost revenue by putting an army salesman on the road to introduce farm families to a world of new conveniences

Bust the Trust

- Willkie's plan was risky, and indeed C&S had some perilous financial times as a result, but
  - It was largely successful with monthly customer power use nearly doubling between 1935 and 1942
  - And it completely changed the way of life for many rural Americans
- Other utility conglomerates, however, did not follow the same approach, instead using their market power to bolster profits by raising rates
- FDR's Trust Busting PUHCA and Public Power initiatives (TVA) were a direct result

Roosevelt v. Willkie

- Willkie, was a Democrat who had voted for FDR in '32, but he soured on the New Deal, particularly as to FDR's advocacy for public power, he was an outspoken critic
  - The New Deal's Tennessee Valley Authority was placed squarely in C&S territory and PUHCA would break up C&S
- By 1939 he had changed parties, and became an important liberal Republican pushing for greater support of Britain's war against Hitler and repeal of much of the New Deal
- At the 1940 Republican convention he was the unlikely nominee on the 6th ballot of a deadlocked party
  - Conventional and more conservative candidates NY Atty Gen Thomas Dewey, and Senators Robert Taft (Ohio) and Art Vandenberg (Mich) could not muster a majority

Roosevelt v. Willkie

- A man who had never held any elected office or been a General became a major party candidate
- Willkie garnered more votes than any losing candidate ever had
  - 22.3 million to FDR's 27.3 million, but in the end carried only 10 states
  - He lost in part because FDR's Lend-Lease Act, which aided the British, had taken away one of his big issues, but mostly because the majority of Americans really were better off thanks to the New Deal

Politics Aside

- Despite his battle with FDR, Willkie fully supported FDR's war effort and made a world tour of all the Allied countries on FDR's behalf in 1942
  - He rallied the troops and made sure the Allies understood that America was united in support of the war effort
- Willkie died suddenly in October 1944 from a heart attack, just 6 months prior to FDR's death at Warm Springs, GA in April 1945

Post War Powering Up

- Although new dams were not built after the war, many existing sites, including Lyons were refurbished and put into to high gear to fuel Michigan's booming auto based economy

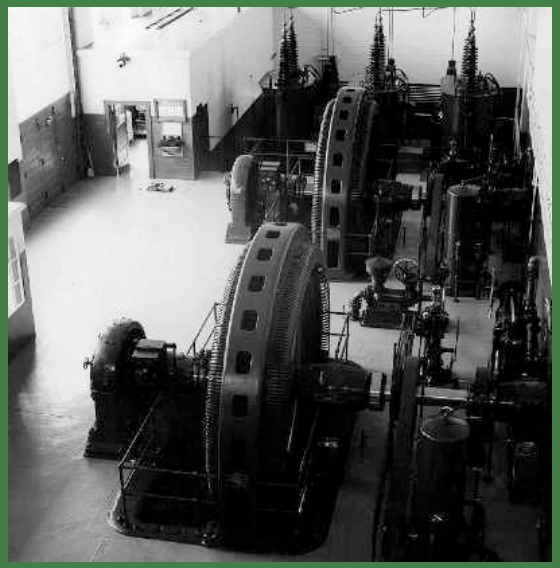
Lyons Dam headrace undergoes repairs in November 1944

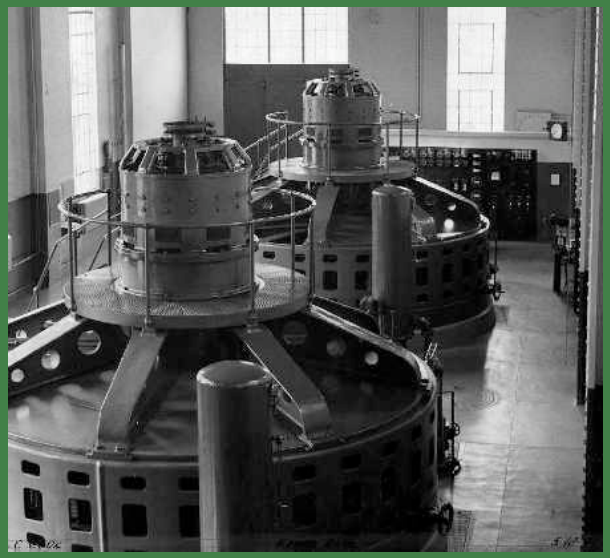
Lyons Dam in Production

Lyons Power Plant - 1944

Lyons Dam control panel

Power Source





- The units typically used were Francis turbines, which could be arrayed horizontally (top photo) or vertically
- The turbine was then connected to the generator, which is the part of the units visible here

Power Source

- The Lyons generator was probably a small unit like this one in the range of 400 to 600 kW
- These units are remarkably dependable with hundreds and perhaps thousands of 80 to 100 year old units continuing to operate today

How Much Power?

- Exact records for Lyons have been lost, but it probably produced around 4 to 5 million kW hours of electricity annually
- Today that is only enough for annual power needs of about 450 to 600 homes, but 60 or 70 years ago it would have served 10 times that number

Other Nearby Dams

Wagar Dam - 1944

Hubbardston Dam - 1944

Other Nearby Dams

- In conjunction with the dams Consumers typically built homes for the plant operators and their family
- Like this house that once stood at Wagar Dam, they were nearly all "kit homes" purchased from the Sears and Roebuck catalog

Operators had to be on site because the plants were operated to respond to power demand. That's very different from today's operation, which balances environmental and power needs

Other Nearby Dams

- Hubbardston Dam on the Fish Creek was built in 1920
  - Consumers bought in 1926 from the Community Light and Power Company, which had formerly been the businesses of Shepard Mill and Slocum Mill
  - Consumers operated it until 1956 when they sold it to the Village of Hubbardston
- Wagar Dam on the Grand River was built some time prior to 1900
  - Consumers bought it in 1925 from the Ionia Water Power Company
  - Wagar was retired in 1956 and the dam demolished shortly thereafter. The site was sold to a private citizen in 1959

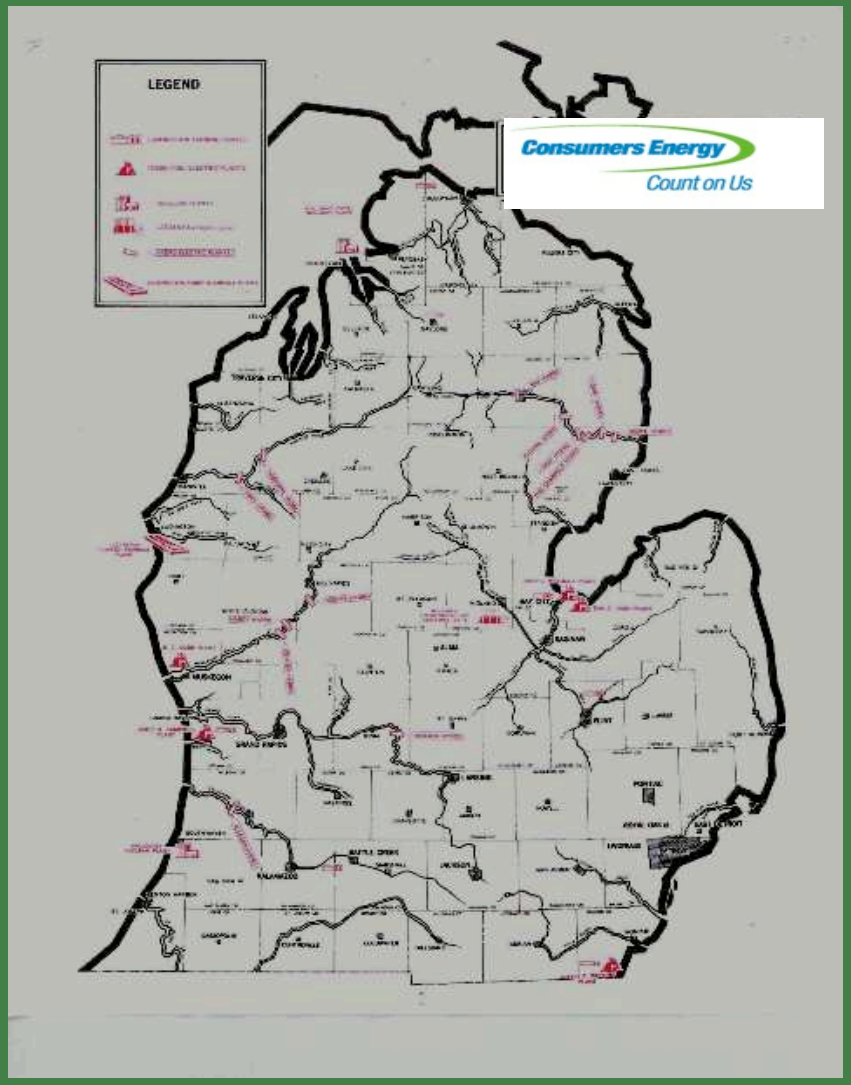
Lyons Dam

- Consumers operated Lyons from 1929 after it was rebuilt until 1957 when it was retired
- The dam was then sold to the Village of Lyons in 1960

What Led to these Retirements

- The small production capability and scattered nature of the dams were a factor
- The biggest driver, however, was federal licensing requirements
  - Obtaining a FERC license is a costly process and could not be justified for the small production dams

Generation Portfolio



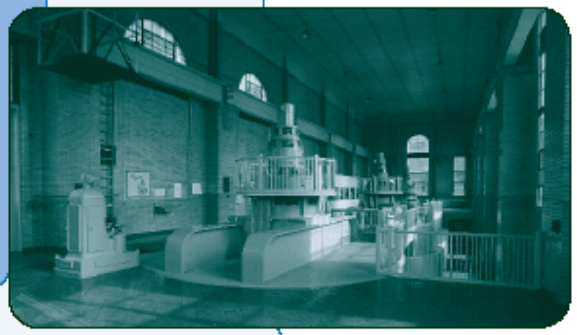
- Today, Consumers continues to own and operate 13 river hydropower projects on the Manistee, Muskegon, Au Sable, Grand and Kalamazoo Rivers as part of its diverse generation mix that includes coal, gas and nuclear plants
- Hydro provides a unique "black light" system restart capability

Today – A Fine Balance

Balancing Flows and Power Production Along the Muskegon

If NO MAN is an island, the same goes for the company's hydroelectric plants. Each is unique, yet all are connected by the rivers that run through them and the complex set of relationships they share with each other.

In balancing flows and coping with reservoir fluctuations, flood control and winter ice, you cannot just consider one hydro. You have to look at the whole picture.



Hardy Dam's three 10-megawatt turbines provide peaking power to meet customer demand.

The Rogers, Hardy and Croton Dams on the Muskegon River are a great example of this system of close relationships. Together, they offer the full range of plant operations that grew out of the 1994 Federal Energy Regulatory Commission (FERC) licenses for the Au Sable, Manistee and Muskegon River plants.

The Muskegon River units form an integrated and complex operation where the inflow to Rogers Pond and the tailwater flow below Croton Dam largely control the operation of the three plants in-between. Rogers operates as a run-of-river plant, Hardy is a full-peaking plant with a winter drawdown, and Croton is a re-regulation plant. But what does all that really mean and how does it affect ice, floods, fluctuations and flows?

Essentially, run-of-river means that the Rogers plant is passing about the same amount of water that is flowing into the Rogers Pond at any point in time. The plant's four generating units are either put online or taken offline, and their governor settings adjusted as needed, to match the incoming and outgoing flow rates. As a result, the Rogers Pond water level fluctuates less than two inches per day. In hydro-speak, the pond has a low fluctuation level.

Run-of-river operation means that water below Rogers Dam is flowing at about the same rate as it would if the dam were not there. Aquatic life in the downstream river segment experiences water flows that follow the natural precipitation patterns. As a result of this form of operation, however, the 440-acre Rogers Pond reservoir has no flood storage capacity. It also means that Rogers' operation has no significant effect on ice jams that sometimes occur upriver.

The Hardy Plant is at the other end of the hydro operations spectrum. It is run as a full-peaking plant. This means using the river's flow on a daily basis to run the plant when there is the greatest demand for electricity. This type of operation — the most efficient for power production — was once commonly used at most hydro plants. It responds to two key realities about producing electricity. First, there is no way to store large quantities of electricity, yet it must be there whenever the switch is flipped. Second, much more electricity is used during the day when manufacturing, commerce and home life are buzzing than during the quieter nighttime hours.

Full-peaking operation, which stores water in the reservoir at night and then runs it through the generators during the day, best responds to electricity's storage

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Balancing Flows and Power Production Along the Muskegon

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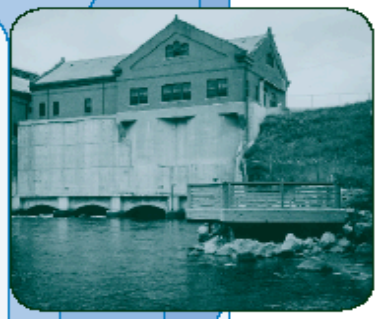
limitations. These days, peaking is avoided because it results in large changes in daily flow rates, which can imperil aquatic life downstream from the plant. However, where there is another hydro reservoir immediately downstream, that daily change in flow has little effect other than to cause some water level fluctuation in the downstream reservoir. That's the case with Hardy Dam, where the reservoir created by the downstream Croton Dam backs up to the Hardy Dam, and there is no river segment between the two plants.



Peaking flows from the Hardy Plant are re-regulated at the Croton Plant to achieve run-of-the-river flows in the Muskegon River downstream.

Consequently, Hardy Dam can be operated safely as a peaking plant. At night its three generating units are normally idle; the water that flows into the reservoir is stored for use the next day. Daytime, Hardy is run at its most efficient settings to maximize electricity production during the period of greatest demand, based on the amount of stored water available. Because of its relatively large 3,902-acre reservoir, Hardy can be efficiently operated as a peaking plant with limited water-level fluctuation of its pond – only about four inches per day.

A special aspect of the Hardy operation is its winter drawdown. March and April in Michigan usually means high river flows from snow melt and spring rains. Because of its size, the Hardy reservoir is able to store a portion of the high spring flows and dampen the impact on properties downstream. Hardy's ability to do this depends on drawing down the reservoir during the winter months to create extra capacity.

Hardy's FERC license allows a reservoir drawdown of up to 12 feet, beginning Jan. 1 each year. However, the license also requires that Hardy Pond be refilled to its normal level by the end of April. Consequently, the extent of the annual drawdown is evaluated throughout the winter. It is based on a combination of experience, weather predictions, the amount of snow in the upstream Muskegon River basin and the water content of the snow. Needless to say, this is not an exact science. Also, if heavy rains fall in late April and May, after the Hardy Pond reservoir has been refilled to its normal level — as happened in 2004 — there is no place to store the higher flows and they must be passed downstream.

The Croton Plant operation is referred to as re-regulation. Croton takes the peaking flow effect from Hardy and re-regulates it so that the Muskegon River flow rate below Croton approximates the natural flow rate. To achieve this result, the 1,200-acre Croton Pond is allowed to rise during the day, when the Hardy Plant is peaking, and is drawn down during the night as the Croton Plant continues to run while the Hardy units are idle. The Croton Pond daily fluctuation is normally about nine inches. As a result, the Muskegon River flows below Croton are essentially run-of-river. Croton Pond has no capacity to store high flows from periods of heavy rain.

The target flow rates for the Muskegon River below Croton Dam are calculated using daily average flows from the upstream Hardy Plant and adding flows entering the Croton Pond from the Little Muskegon River. The readings are continuously updated and relayed between the plants, where they are displayed on a computer screen. The Croton outflow rates are then measured at a river gauge located in the tailwater below Croton Dam.

This coordinated hydro operation along the Muskegon River ensures that the Croton tailwater flows meet the run-of-river targets that protect and enhance aquatic habitat. Within that constraint, the Rogers, Hardy and Croton Plants are operated to maximize their renewable energy production for the benefit of Michigan's citizens.

Renewable Energy Production

- Average annual production from Consumers' 13 river hydro projects is about 406 million kilowatt hours
  - That's enough to serve the annual power needs of 50 to 55 thousand residential customers
- To produce an equivalent amount of electricity we would need to:
  - Burn 4 billion cubic feet of natural gas
  - Build and operate 185 one-megawatt wind turbines

Consumers Energy

Hydro Generation

More Information

- For more information on Consumers' and Michigan's hydropower history:
- Future Builders
  - by George Bush
  - Copyright 1973 by McGraw-Hill

- For more information on Wendell Willkie
- www.usfamily.net/web/timwalker/sitedocs/home.html
  - Tim Walker is a descendant of Willkie's and does a wonderful job on this site of providing an overview of Willkie's life