# 2020 INTEGRATED RESOURCE PLAN

Strategic Planning & Development

LANSING BWL
Hometown People. Hometown Power.

# Table of Contents

## Table of Figures

# List of Tables

# Executive Summary

## Introduction

The Lansing Board of Water & Light's (BWL's) 2020 IRP is a long-term, 20-year plan that provides guidance on how best to meet its customers' future electric energy needs. This 2020 IRP incorporates key components of the Board's mission in the development of plan goals and metrics. This 2020 IRP is the latest planning initiative that has included the 2008 and 2016 IRP's and the 2016 Strategic Plan and which have resulted in retirement of BWL coal units while adopting a diverse set of generating options. It also sets the stage for the next step in environmental stewardship by embracing the challenge of climate change with a recommendation to pursue carbon neutrality by 2040[1].

## About the Lansing Board of Water and Light

The Board's mission and values reflect those of the BWL's customers and include affordability, reliability, sustainable growth, and environmental stewardship. The BWL's roots go back to 1885 when Lansing citizens approved building a water system. Electricity was added to BWL's list of utility services in 1892, and steam heat in 1919. Chilled water service was added in 2001.

The BWL owns 2,000 miles of overhead and underground power lines and more than 800 miles of water mains, providing 2.7 million megawatt-hours and 7 billion gallons of water to customers annually.[2] The BWL has more than 97,000 electric and 56,000 water customers throughout the greater Lansing area.

## Public Ownership

The BWL is governed by a Board of Commissioners, made up of eight local citizens appointed by the Lansing mayor and approved by the city council. The Board expanded in 2014 to include three non-voting members representing areas of our service territory outside the City of Lansing. The BWL's connection to the community through its citizen/customer Board has been an impetus for the BWL's leadership in the utility industry. Pride in public ownership has helped the BWL become an integral part of the Lansing community's social and cultural environment while providing essential utility services.

## Objectives

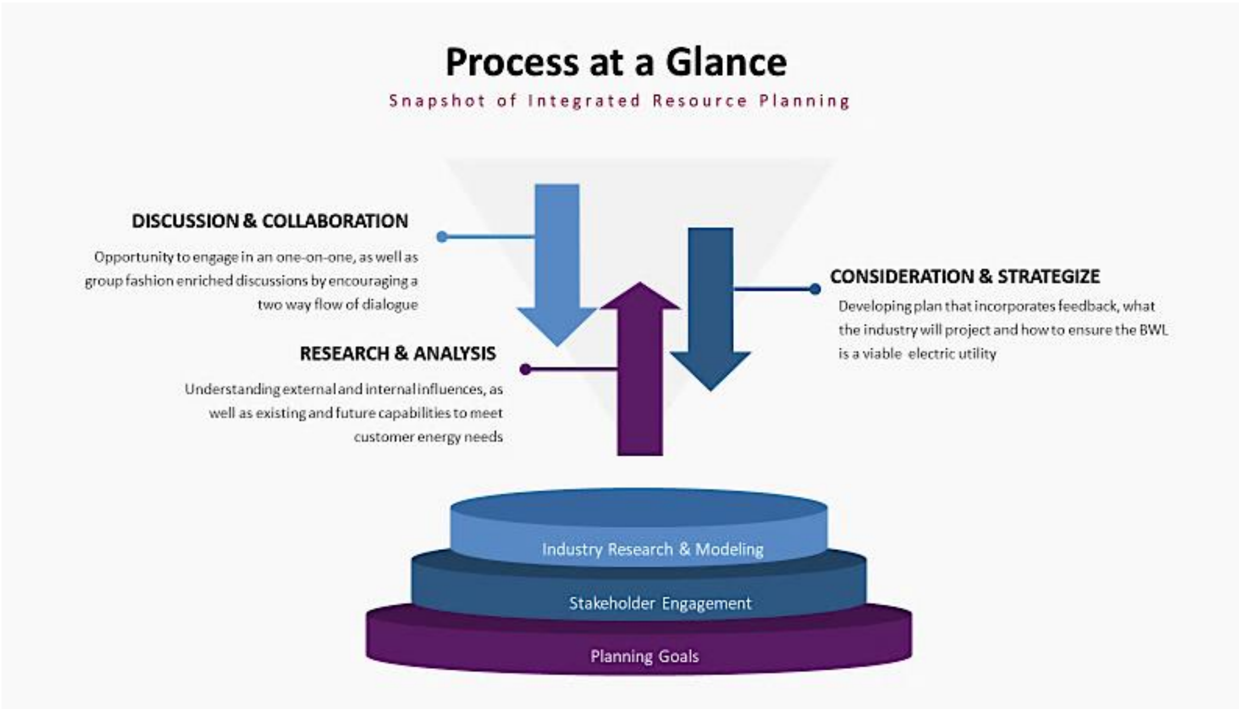
The objective of this IRP is to identify, evaluate and recommend a resource plan that performs best with a variety of possible future events and conditions while meeting goals related to cost and risk, reliability, operational flexibility, and environmental, including climate impacts. This process involves evaluating generating resource capabilities, developing resource strategies and scenarios for modeling, and understanding the current state of the industry along with industry trends. Figure 1 provides a high-level overview of the IRP process.

---

[1] Carbon neutrality is also referred to "net zero" carbon emissions.

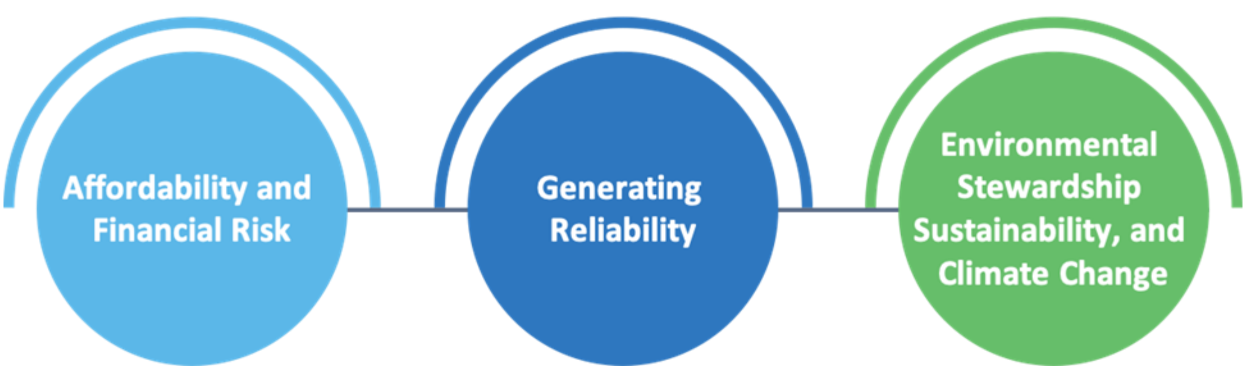
[2] Electricity sales include sales for resale.

*Figure 1: Process at a Glance*



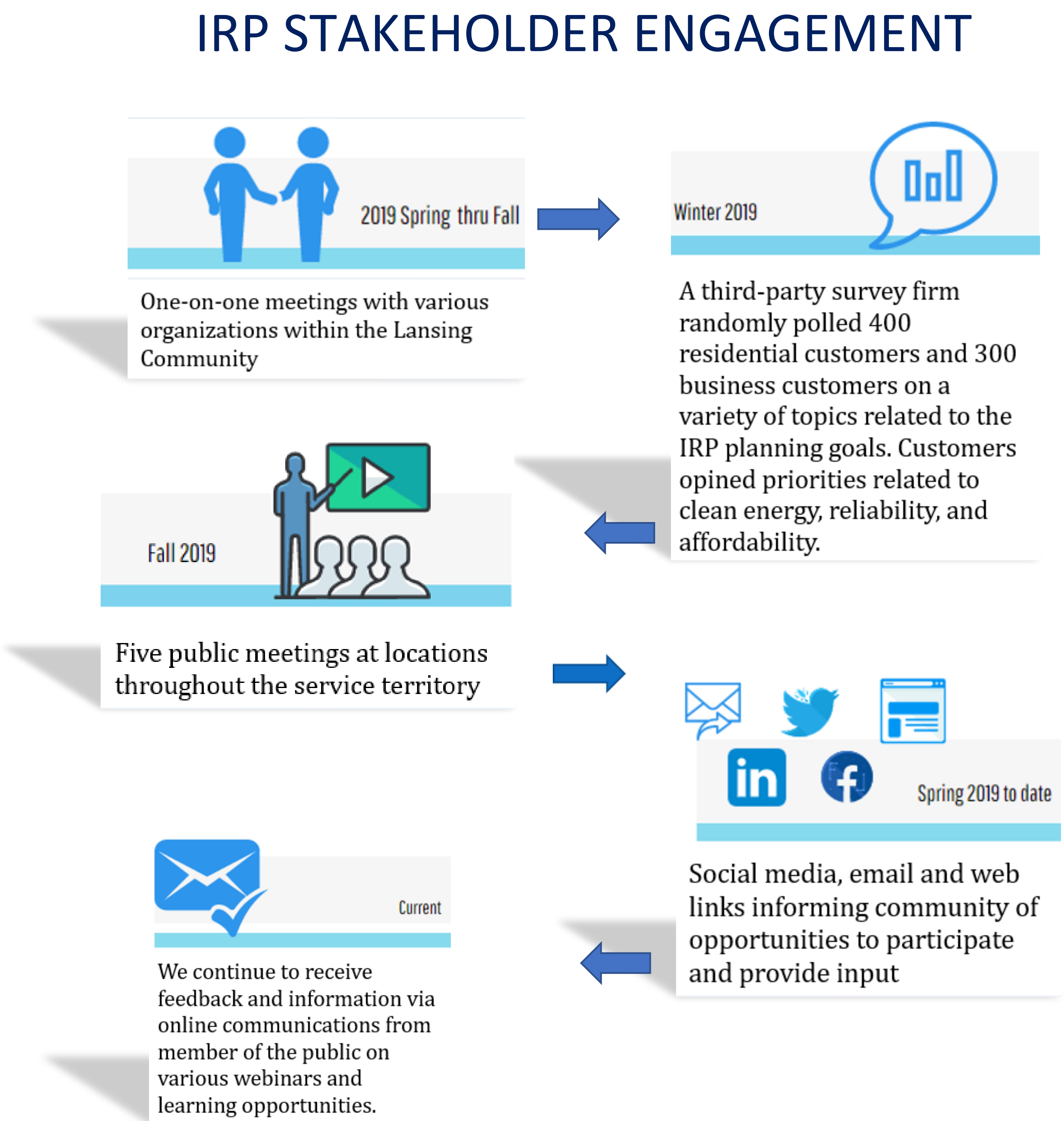

The BWL began this IRP process through a comprehensive outreach program to inform and encourage customer participation. Customer input was used to help define the goals and scope of the IRP. The primary goals adopted for the IRP are shown in Figure 2 and harmonize with the BWL's mission as well as customer recommendations. These goals serve as the basis for metrics that were used to assess the modeling results of the various resource strategies and sensitivities and in making a recommendation.

*Figure 2: IRP Planning Goals*




The IRP used multiple channels to engage customers in the process. Figure 3 depicts the schedule and approaches used by the BWL to encourage public participation.

*Figure 3: IRP Stakeholder Summary*




## Ability to Meet Customer Needs

The BWL's ability to meet customers' future electricity needs begins with forecasting customer electric energy and peak demand over the next 20-years. While population and business growth, energy waste reduction[3] programs and customer sited generation factor into forecasted needs, the future of electric

[3] Also referred to as energy efficiency programing.

transportation and space conditioning are emerging trends that will also have a direct impact on future electricity sales.

Forecast energy is the amount of electricity that customers are estimated to consume or need over a future period, like one month or one year, and are expressed as megawatt hours (Mwhs). Consumption of electric energy is characterized by “peaks" and "valleys" that vary with time. "Peaks" refer to those times with the highest demand for electric energy, and "valleys" refer to those times with the lowest demand for electric energy.

Capacity is the amount of generation that is available at a point in time. Peak energy use is an important determinant of the BWL’s capacity needs, since it must have sufficient generation capacity available to meet its peak demand. Another important component of the BWL’s capacity requirement are mandatory national reliability standards for electric utilities. The objective of generation planning is to ensure the BWL can generate enough electricity to meet those "peak" moments and the reliability standards. Capacity is needed for unexpected increases in demand and to replace generating facilities that may suddenly experience a forced outage.

A comparison of the BWL’s forecast energy and capacity needs with its currently available generating assets, owned and contracted, indicates that the BWL could meet its customers electricity requirements and mandatory, capacity standards until 2030. However, not all existing generating resources may be available over the coming years. Existing generating assets, especially older units, may be retired because of high operating and maintenance costs in an era of low market energy prices or because of capital additions that may be necessary to comply with various regulations. To determine a least cost portfolio of generating assets that best meets the IRP’s goals, the IRP includes extensive modeling by incorporating several strategies and resource sensitivities.

## Modeling for the Future

To ensure the BWL's plan for meeting customers' needs satisfies the primary planning goals, extensive modeling was included in this IRP. This involved developing four resource strategies. Each strategy represents a distinct plan for meeting future needs. For example, one strategy is to adopt the goal of 50% clean energy, consisting of renewable energy and energy waste reduction, by 2030. The modeling program then determines the least cost way of achieving that goal. The modeling program also includes resource sensitivities with some strategies. The sensitivities adopt one or more resource or incentive requirements for a strategy. For example, a sensitivity may specify a predetermined level of energy waste reduction or enhanced incentives for distributed generation.

The strategies are: 1.0 current resource plan adopted in the 2016 Strategic Plan, 2.0 representing the State standard for renewable energy and energy waste reduction, 3.0 adopting a 50% clean energy goal for 2030, and 4.0 adopting a 50% renewable energy goal by 2030. Strategies 1.0 and 3.0 include additional resource sensitivities that adopt one or more resource or incentive levels as requirements. Each strategy along with the sensitivities produce a portfolio of resources. Metrics are then used to evaluate the resulting portfolios.

The IRP allowed the modeling program to select from a variety of resource options to meet the IRP goals. Resource options included in the IRP are shown in Figure 4.

*Figure 4: IRP Resource Options*


In this 2020 IRP, the BWL's modeling program made use of a stochastic model. In this stochastic model strategies and resource sensitivities are tested by modeling 100 different model futures where variables change in a probabilistic manner. By so doing, the model explicitly addresses future uncertainty and risk. Figure 5 below shows the IRP metrics used to evaluate the strategies and sensitivities.

*Figure 5: IRP Metrics*

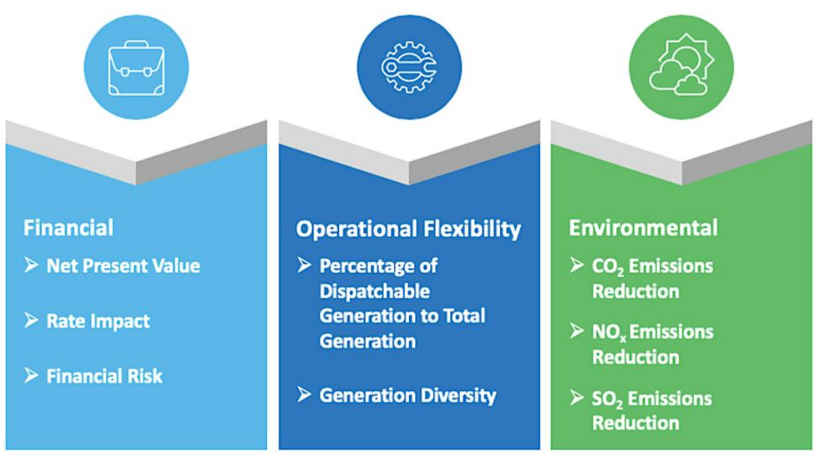


Table 1 identifies and explains the strategies and resource sensitivities modeled in this IRP and the purpose of each.

*Table 1: IRP Strategies and Resource Sensitivities*

| Strategy | Description | Purpose |
|---|---|---|
| **1.0 Reference** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, 1% annual energy waste reduction, all other options optimized | Reference case incorporates current resource plan |
| **1.1** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2021, 1% annual energy waste reduction, all other options optimized | What is the impact of Erickson early retirement on the reference case? |
| **1.2** | Current plan 30% clean energy by 2020, 40% in 2030, Erickson retirement 2021, maximum cost-effective energy waste reduction (all 5 bins), all other options optimized | What is the effect of maximum energy waste reduction (all 5 bins) on the reference case with Erickson early retirement? |
| **1.3** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, minimum energy waste reduction (bin 1 only), all other options optimized | What is the effect of reducing energy waste reduction (bin 1 only) on reference case? |
| **1.4** | Current plan 30% clean energy by 2020, 40% in 2030, Erickson retirement 2025, maximum energy waste reduction (all 5 bins), all other options optimized | What is the impact of maximum energy waste reduction (all 5 bins) on the reference case? |
| **1.5** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, 1% annual energy waste reduction, high peak demand growth, all other options optimized | What is the impact of higher customer peak demand growth on the reference case? |
| **1.6** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, 1% annual energy waste reduction, high incentives for electric vehicles, all other options optimized | What is the impact of incentivizing electric vehicle adoption on the reference case? |
| **1.7** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, 1% annual energy waste reduction, high incentives for customer onsite distributed generation options, all other options optimized | What it the impact of incentivizing distributed generation on the reference case? |
| **1.8** | Current plan 30% clean energy by 2020, 40% in 2030, Erickson retirement 2025, maximum energy waste reduction (all 5 bins), high incentives for electric vehicles and customer onsite distributed generation, all other options optimized | What is the impact of maximum energy waste reduction (all 5 bins) on the reference case? |
| **2.0** | State standard of 15% renewable energy through 2021 and minimum energy waste reduction (bin 1 only) | How does the reference case compare to the State requirements? |
| **3.0** | 30% clean energy by 2020, 50% in 2030, Erickson retirement 2025, 1% energy waste reduction, all other options optimized | What is the impact of increasing the clean energy goal to 50% on the reference case? |
| **3.1** | 30% clean energy in 2020, 50% in 2030, Erickson retirement 2025, maximum energy waste reduction (all 5 bins), all other options optimized | What I the impact of increasing the clean energy goal to 50% on the reference case including maximum energy waste reduction (all 5 bins)? |
| **4.0** | 30% clean energy in 2020, 50% renewable energy in 2030, Erickson retirement 2025, 1% energy waste reduction, all other options optimized | What is the impact of increasing the renewable energy goal to 50% on the reference case? |

## Recommendations

For near-term decisions over the next 5 to 10 years, the goal of 50% clean energy in 2030 (Strategy 3.0) scores well with the IRP metrics. Though slightly more expensive than the reference case in the first 10 years, it is less costly and less financially risky over the 20-year period. It also represents a balance by providing more generating diversity and fewer emissions. In addition to wind and solar projects now being developed for the BWL, the goal of 50% clean energy in 2030 will not require additional projects until 2025. It includes the continuation of the Hometown Energy Savers energy waste reduction program.

The recommendation includes a measured, consistent growth in the Hometown Energy Savers energy waste reduction program. The maximum energy waste reduction contributes to lower present value revenue requirements over the long-term. An additional advantage of the energy waste reduction program is that as it displaces both thermal and renewable energy investment. These investments are long-term fixed cost commitments. Over a longer time, managing these commitments provides financial and operating flexibility to the BWL. This advantage should be a consideration in planning future energy waste reduction programs as part of a plan to reach 50% clean energy in 2030.

The IRP metrics demonstrate that significant emission reductions in all 3 measured emissions will occur in the first 10 years of the plan. This provides an opportunity to pursue the goal of reaching carbon neutrality in 2040.

Carbon neutrality includes both reducing carbon emissions and mitigating, or offsetting, carbon emissions when elimination of emissions is not practical. By adopting this goal, the BWL would join major U.S. utilities, non-utility companies, States, Cities, and Countries that adopted a carbon neutral goal. This goal would face challenges and depend on technology improvements to continue balancing all the BWL's planning goals. However, over the next 20 years, it is reasonable to project that continued technological improvements in energy production and storage will occur. While a defined plan for carbon neutrality is yet to be explored, a process that identifies and incorporates these improvements into an ongoing carbon neutral plan is the BWL's future.

This IRP has identified several trends and studies that are necessary for future planning.

## Distributed Energy Resources

Undertake a comprehensive study of the BWL's distribution system in preparation for more extensive distributed generation and electrification.

## Customer Energy Management

Monitor and assess customer energy-related technology options that may impact customers' ability to manage energy use.

## Additional Measures of Progress

Further develop metrics to provide for more transparency and to help guide its resource recommendation and involve customers in the process.

## Carbon Neutrality Plan Development

Perform detailed study to determine methods, options, schedule, and costs for reaching carbon neutrality in preparation for the next IRP.

# Integrated Resource Plan (IRP)

The Lansing Board of Water & Light's (BWL's) 2020 IRP is a long-term plan that provides guidance on how to best meet its customers' future electric energy needs. It is a valuable tool for assuring that the BWL can continue to fulfill its mission to the Lansing community in an evolving energy industry. This 2020 IRP incorporates important components of the BWL's mission as goals and include planning metrics based on those goals to aid in making a recommendation. The metrics have been selected to help evaluate alternate generation strategies for conformity with BWL's mission of reliability, affordability, sustainable growth, and environmental stewardship. These correlate strongly with the goals that our customers have recommended for this plan.

The plan develops four principal strategies for meeting future electric capacity and energy needs. Development of the strategies is timely since Michigan's municipal utility renewable energy and energy waste reduction goals change after 2021. Beginning in 2022, the State's municipal renewable energy standard is fixed at 15% and the municipal energy waste reduction planning, reporting, and enforcement requirements terminate. These changes together with other events occurring in the industry pose questions about the role of renewables and energy waste reduction and how to respond to new technologies and changing customer preferences. Each strategy is tested against the BWL's long-term, 20-year, energy and peak demand forecasts to determine which group of resources produce the least cost plan that manages future uncertainty and meets financial, operational, and environmental planning goals. Like previous IRPs, the BWL has actively sought participation from a diverse set of customers and stakeholders through several channels. Stakeholder input was used to help develop the plan's scope and metrics.

## Lansing Board of Water & Light Community Roles

The BWL was created by the citizens of Lansing in 1885 to provide water and, in 1892, electric service to the community. During these early years, most citizens were without electricity but there was a growing interest and demand for the new electric service. To help meet the growing demand, leading members of the Lansing community proposed electric service from a public entity. They believed that a public entity, operated like a business, could be a benefit to the community by providing electric service to more people and do so more economically than a private, unregulated firm[4]. That belief began the BWL's connection and commitment to the Lansing community.

As in other growing communities, the BWL's electric operations increased rapidly to meet Lansing's demand for electricity. Fueled by rapid population and economic growth, Lansing's consumption of electric energy doubled every few years. Lansing's early economy relied heavily on the BWL's generating plants. This was exemplified in 1921 when General Motors donated 9 acres of land to the BWL for a new power plant. The plant stood where the BWL's Eckert power plant now stands, adjacent to GM's Grand River assembly plant. The 1921 power plant was designed to supply both electricity and steam to General Motors and other customers near downtown Lansing. The BWL has grown to be Michigan's largest

[4] The Michigan Legislature first authorized the Michigan Railroad Commission to regulate electric utilities in 1909.

municipal electric utility and among the nation's largest 30 in customers[5]. Its mission has remained to deliver safe, affordable, reliable power to the Lansing Community, and in today's world cleaner energy.

Beyond water and electricity production and distribution, the BWL has been a central figure in the social and cultural development of the Lansing community. As a local, public entity, it has served as an integral part of the community through activities like the *Pennies for Power*, *Community Solar, Do1Thing Emergency Preparedness, Adopt A River, Silver Bells in the City* and the *Chili cookoff*, promoting opportunities for area students through the *1St Step* program and summer internships, and hundreds of hours of volunteer work from its employees.

The BWL's Board of Commissioners, composed of residents, has been responsive to the community's health and welfare along with its energy interests. For example, adopting the State's first renewable energy standard and being the second city in the United States to voluntarily remove all lead service lines from its water customers' premises. It is with this connection to the Lansing community, that the BWL undertook this IRP.

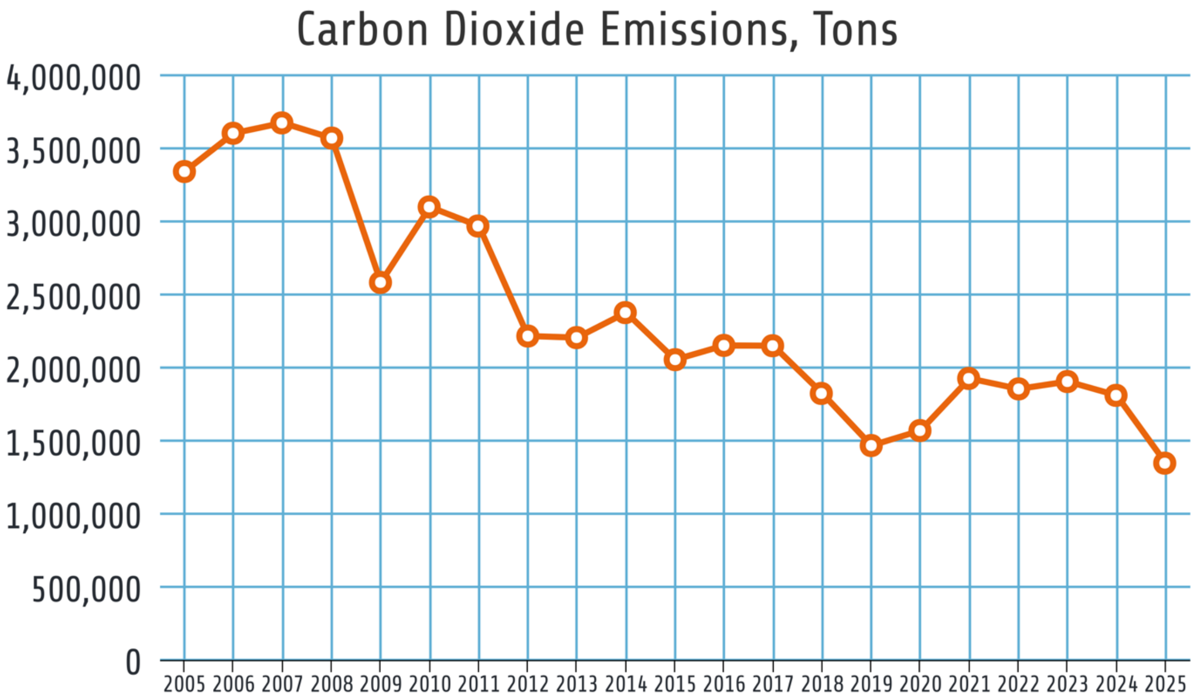
## Recent IRP's and the Start of the BWL's Clean Energy Journey

In the late 1990's, the BWL began a clean energy journey to change the way it provides electric energy to the Lansing community while also maintaining its commitment to affordable and reliable electricity. This IRP is the next step in a process that is intended to move the BWL to carbon neutrality over the next 20 years. There are many more steps to come to ensure that the appropriate technology and opportunities will be available and technology economics will permit the BWL to meet that goal while keeping rates affordable to all its customers. Subsequent IRP's will analyze and evaluate emerging technologies and future resource options. It may also mean that the way the BWL goes about its business may also be changing in the coming years. This and subsequent IRPs will serve to inform BWL's commissioners when facing those issues.

Figure 6 demonstrates the BWL's commitment to reducing its $CO_2$. The figure shows the reduction in $CO_2$ from a 2005 base year, the year used by the United Nations Framework Convention on Climate Change to measure carbon reductions, and current projections for the next 5 years. The BWL's customer-owners have indicated that this is an important part of a comprehensive energy plan and, as a community organization, it is a central part of our long-term goals.

[5] Among publicly owned utilities that serve retail load.

*Figure 6: CO2 Emissions Reductions 2005 to 2025*




## 2008 IRP: Recommendation for the REO Town Cogeneration Plant

Since it began electric operations in 1892, the BWL has relied on coal-based generation to serve the Lansing community. That began to change with an IRP initiated in 2008. The 2008 IRP included a Citizen Advisory Committee composed of local citizens to review and make recommendations to the BWL's initial IRP findings. The Committee recommended the BWL examine natural gas generation options and the possibility of a cogeneration facility. The recommendation led to the development of the REO Town natural gas fired cogeneration plant. REO Town was designed to replace three coal fired electric generation boilers and three coal fired steam production boilers used for the BWL's central steam system. Fueled by natural gas, REO Town operates far more efficiently than the coal boilers that it replaces with a fraction of emissions. In 2013, the REO Town plant was awarded the Engineering News Record Midwest's Industrial/Energy Project of the Year award.

## 2015 IRP: Lansing Energy Tomorrow Program Inception

The 2008 IRP was followed by the 2015 IRP, which again included a Citizen Advisory Committee. The 2015 IRP commenced the "Lansing Energy Tomorrow" program, which included replacing the last three coal fired generating units at the BWL's Eckert station and major transmission and distribution upgrades. The Citizen's Advisory Committee recommended a diverse set of generating options including 90 MW of wind generation, 140 MW of solar power, energy waste reduction investment, and new natural gas generation. The recommendations in the 2015 IRP played a key role in development of the BWL's 2016 Strategic Plan Update.

## 2016 Strategic Plan

The 2016 Strategic Plan involves nearly every aspect of the BWL's operations. Among the many objectives of the plan is a 30% clean energy goal in 2020, consisting of energy waste reduction and renewable energy, and increasing clean energy thereafter. It also includes a new natural gas fired generating plant that would permit the BWL to retire all its coal generation by the end of 2025. This new plant, the "Delta Energy Park", serves as an important bridge in a move to carbon neutrality. The result of the 2016 Strategic Plan will be nearly 80% reduction in $CO_2$ emissions by the end of 2025.

## Planning Challenges

Since the 2015 IRP was completed, many changes have been occurring in the electric utility industry and will likely to continue or accelerate in coming years. Customers continue to demand affordable and reliable power, but also want clean power and more individualized energy solutions. Major contributors to this change are customer concern with climate change, the impact that electric generation has had and will have on the environment and the economy, personal and corporate sustainability goals, and technical improvements in onsite generation and energy management.

The declining cost of renewable generation means that reducing greenhouse gas emissions is more affordable and customers have expressed interest in taking advantage of this cost decline. Both residential and commercial customers have begun to either install or consider installation of solar energy on their premises. Known as distributed energy, the BWL will need to integrate this into its distribution system in the coming years.

Michigan's changing economy, more stringent lighting and appliance efficiency standards and the widespread employment of energy waste reduction programs have fundamentally changed the historic growth of electric energy demand. Since the great recession of 2008, the BWL's, growth rate of electricity demand has been comparatively flat, like Michigan and the U.S growth rates. At the same time, there is growing interest in electric powered vehicles and electric space conditioning options (heating and air conditioning). Some customers have expressed an interest in net zero carbon facilities that would use renewable electricity to replace natural gas for heating. These developments may auger more electric demand growth in the future, adding more uncertainty to the planning process.

The role of communications technology is also affecting consumer demand for electricity by enabling customers to more closely monitor and manage their energy use. Thermostats, lighting, and appliances can be controlled remotely through web enabled communications. Together with rate incentives, this ability can be used to manage peak loads an avoid construction of additional generating facilities.

The decline in cost for renewable energy coupled with the decline and moderation of natural gas prices have made coal fired units less economic. As natural gas generation technology has become more efficient and gas prices have declined the dispatch cost of new natural gas units can be less than the dispatch cost of older coal fired units. Together with the low or zero dispatch cost of renewable generators, this has limited the annual economic operating margin of older coal plants decreasing net operating revenue. With comparatively higher fixed costs, these unit find it hard to compete.

One of the objectives of this IRP is to examine these trends and determine their impact on the BWL's future electric generating needs.

## Strategies and Resource Sensitivities

To capture the impact of these trends while also fulfilling the BWL's mission, this IRP incorporates 4 principal resource strategies along with 9 resource sensitives. Each strategy represents a different approach to meeting future customer electricity needs and industry conditions. For example, Strategy 3.0 adopts a 50% clean energy goal consisting of renewable energy and energy waste reduction by 2030. Strategies 1.0 and 3.0 also include resource sensitivities. Resource sensitivities measure the impact of specifying, or fixing, a resource or incentive level for the strategy. For example, a resource sensitivity may include fixing the energy waste reduction level or enhancing a distributed generation incentive for a strategy.

The first strategy is the reference case which begins with the current plan of reaching 30% clean energy in 2020, and includes the retirement of the Eckert plant December 31, 2020, Erickson in 2025, and Belle River in 2029/30. In the reference case, some of the State's requirements to offer energy waste reduction programming terminate at the end of 2021, but the strategy continues an energy savings goal of approximately 1% annually. The remaining 3 strategies have been developed based on stakeholder input and trends occurring in the industry and are intended to answer the following questions.

- What are cost implications of retiring the Erickson plant prior to 2025?
- What is the impact of maintaining or expanding energy waste reduction on the current plan?
- What resources are adopted when the clean energy goal is increased?
- What would be the impact of increasing clean energy on cost and operations?
- What is the likely pace of adoption of distributed generation and electric vehicles in the BWL's service territory?
- Would providing a high level of incentives for distributed generation and electric vehicle sales have a significant impact on resource planning?
- What would be the effect of a consistent peak demand growth driven by electric vehicles and growing electric space conditioning?
- What is the likely impact of demand response programs on the BWL's forecast peak load?
- Will energy storage play a role in managing the BWL's forecast load?

# IRP Process

## IRP Overview

The 4 strategies, along with the resource sensitivities, provide the scope of the IRP and are based on planning goals developed by the BWL after a public process which involved consulting with numerous stakeholders. Not surprisingly, the process results in multiple goals – reliability, affordability, and environmental stewardship. Other goals continue to be preference for local generation and promotion of local economic development.

An important part of the IRP is the use of models to forecast the impact that the strategies may have on the BWL's future finances and operations. This involves developing a reference case, preparing a long-term demand forecast, compiling economic data, undertaking supporting studies, determining strategy evaluation methods, and undertaking extensive computer modeling. For this IRP, the BWL has developed a set of metrics to aid in comparing and evaluating the the resulting portfolios.

The resulting analysis and modeling outcomes, with a recommended resource portfolio, will be made available to the BWL's customers for their comments. The recommendation along with the customer comments will then be provided to the Board to aid in development of a Strategic Plan update. Just as the Board's 2016 updated Strategic Plan plays a role in this IRP, the results of this plan will inform the next BWL Strategic Plan update. The 2020 IRP will be used to examine the amount and acquisition pace of additional renewable energy and energy waste reduction, demand response programs, distributed generation, and prepare the BWL for likely impacts of electric vehicles and electrification of space conditioning technologies. The Board will have this information available to it when it updates its strategic plan later in 2020.

## Public Participation

The first step in this IRP process was a multifaceted campaign to gather public input. As a community-based organization, the BWL has always deemed it important to engage the public in its planning process. The BWL has actively sought input from a broad set of stakeholders to help identify IRP goals, identify potential future risks and trends, learn about customer preferences for generation technology and other considerations that the BWL should include in the IRP.

Beginning in February 2019, the BWL has held 18 one-on-one stakeholder meetings with various organizations within the Lansing Community and additional meetings with numerous individuals. These groups include neighborhood association members, environmental groups, business representatives, local governmental officials, non-profit representatives, and others. The meetings were also used to apprise these groups of the IRP process and their opportunity for input. A complete list of stakeholder groups with whom the BWL has met and a summary of the comments and suggestions received from these stakeholders are included in Appendix A.

The BWL also conducted five public meetings at locations throughout its service territory. Two meetings were held at the BWL's REO Town depot, one in East Lansing, one at the Alfreda Schmidt community center in in south Lansing, and one in Delta township. The public meeting formats were designed to inform attendees on the IRP process, explain the BWL energy waste reduction and renewable energy programs, provide historical background on the BWL's electric generation fleet along with recent developments, and to solicit input from attendees.

The BWL also used social media, Facebook and Twitter, to inform customers of their opportunity to participate in the IRP, to provide information on the BWL's programs, and to invite comments and recommendations to the BWL regarding long-term energy planning. To date, 28 individuals have submitted comments, questions, and recommendations over social media.

Finally, the BWL used a third party, professional survey firm to conduct a survey of customer attitudes and opinions on energy planning topics. The survey firm randomly polled 400 residential customers and 300 business customers on a variety of topics related to the IRP planning goals. Customers opined priorities related to clean energy (renewable energy and energy waste reduction), reliability, and affordability. Residential customers offered strong support for clean energy options as well as affordability. Business customers strongly supported reliability and affordability as a planning goal.

Goals related to economic development and local generation were of interest, though important to customers, were generally of lower priority. Generally, these results are consistent with public input from previous IRPs. The most meaningful change from previous surveys is a marked increase in the support for clean energy. Appendix A has more information on comments received by the BWL as well as the survey undertaken of BWL customers.

The primary goals adopted for the IRP are shown in Figure 7. These goals serve as the basis for metrics that have been used to assess the modeling results of the various strategies.

*Figure 7: IRP Goals*


## Follow-on Studies

The process of compiling data, adopting modeling assumptions, conducting the modeling, projecting future events and issues – in short, conducting the IRP, has led to identification of trends and the need for additional studies in preparation for future planning endeavors. This IRP includes recommendations for these studies:

- **Distributed Energy Resources:** Undertake a comprehensive study of the BWL's distribution system in preparation for more extensive distributed generation and electrification.

- **Customer Energy Management:** Monitor and assess customer energy-related technology options that may impact customers' ability to manage energy use.
- **Additional Measures of Progress:** Further develop metrics to provide for more transparency and to help guide its resource recommendation and involve customers in the process.
- **Carbon Neutrality Plan Development:** Perform detailed study to determine methods, options, schedule, and costs for reaching carbon neutrality in preparation for the next IRP

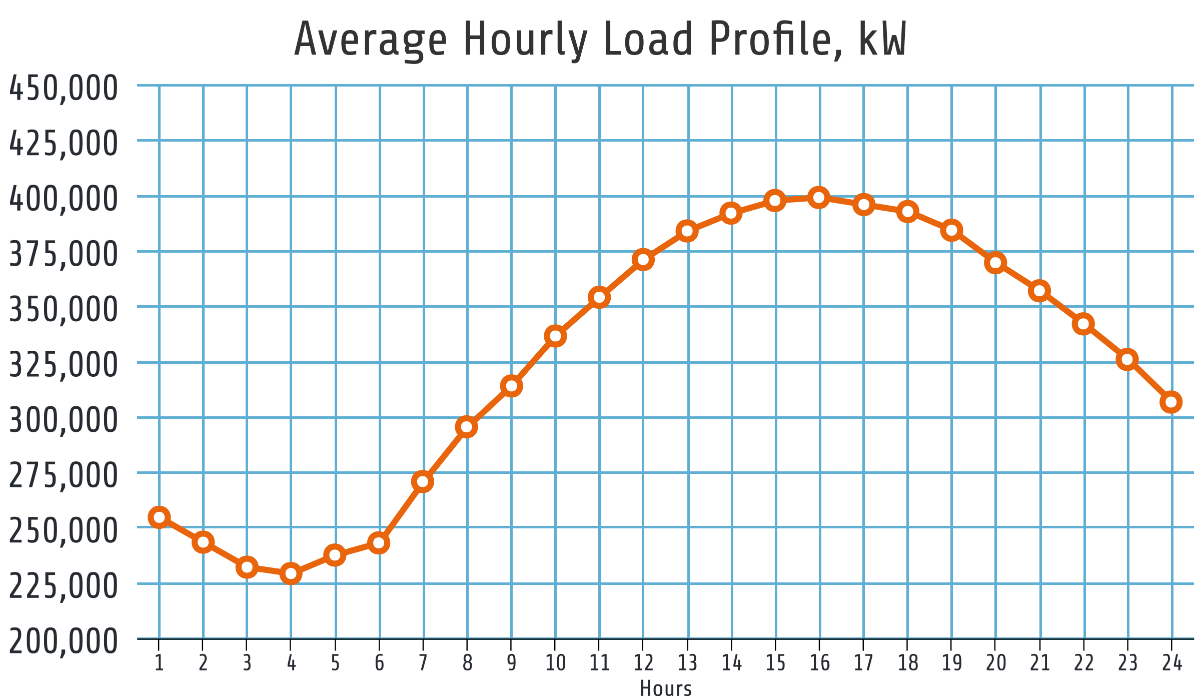
# Resource Adequacy and Generation Reliability

## Customer Demand Variability

Utilities continuously experience fluctuating customer electricity demand. This requires the ability to ramp generation up or down or even bring a unit on-line, if not already operating. If supply is not matched to demand moment by moment, the "grid" can become unstable and even collapse causing considerable damage.

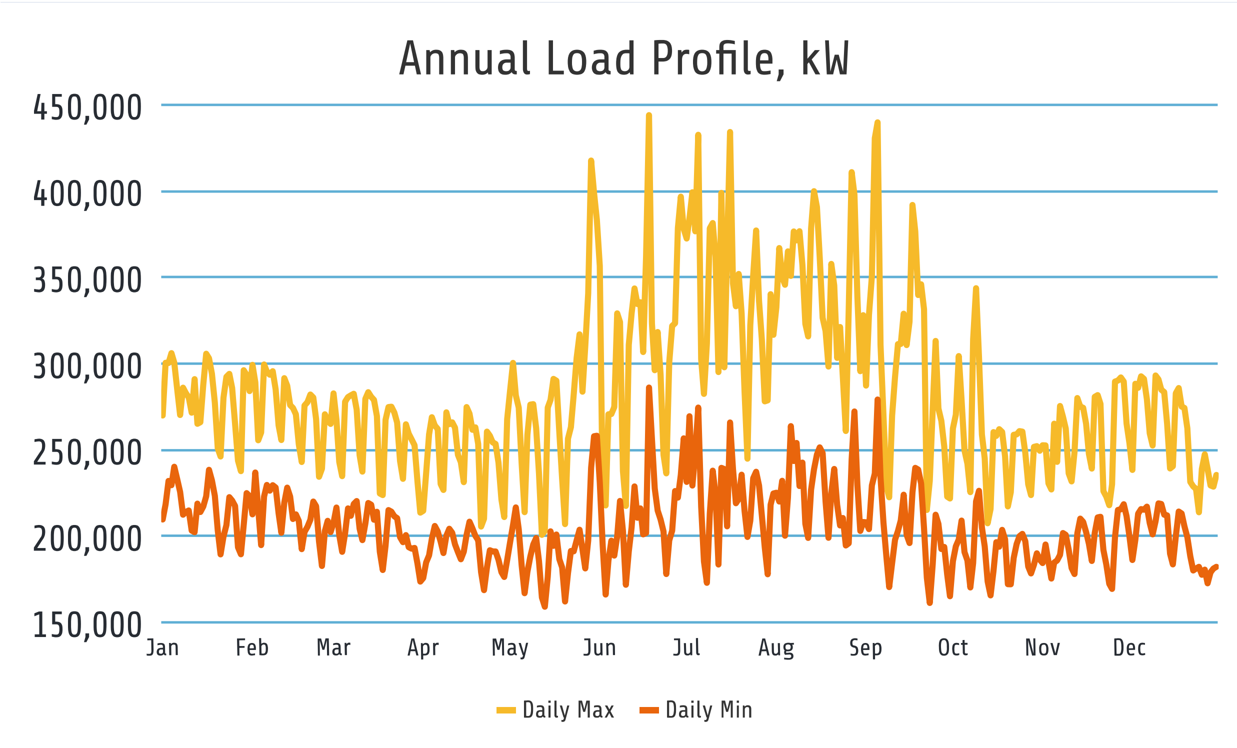
Figure 8 shows a typical daily summer load profile. To keep generation and customer demand in balance, the BWL must have generation that it can "dispatch" to meet load fluctuations.

*Figure 8: Average Hourly Load Profile*




Demand also changes seasonally, being highest, or peaking, in the summer months. There are secondary peaks in the winter months, while the fall and spring are known as "shoulder" months, when demand is usually lower than summer and winter. Figure 9 below shows the maximum and minimum daily demands over one year demonstrating seasonal variations.

*Figure 9: Annual Load Profile*




A key role of the IRP is to assure that the BWL has the right inventory of generating resources to meet demand moment by moment, hour be hour, day by day, month by month, and year by year.

## Determination of Generating Capacity Need

To determine whether additional, future generating resources may be required, the BWL compares its future, available generating capacity to its forecast peak demand requirements. The process begins with a long-term forecast of the utility customers' energy and demand requirements.

## Long-term Forecast

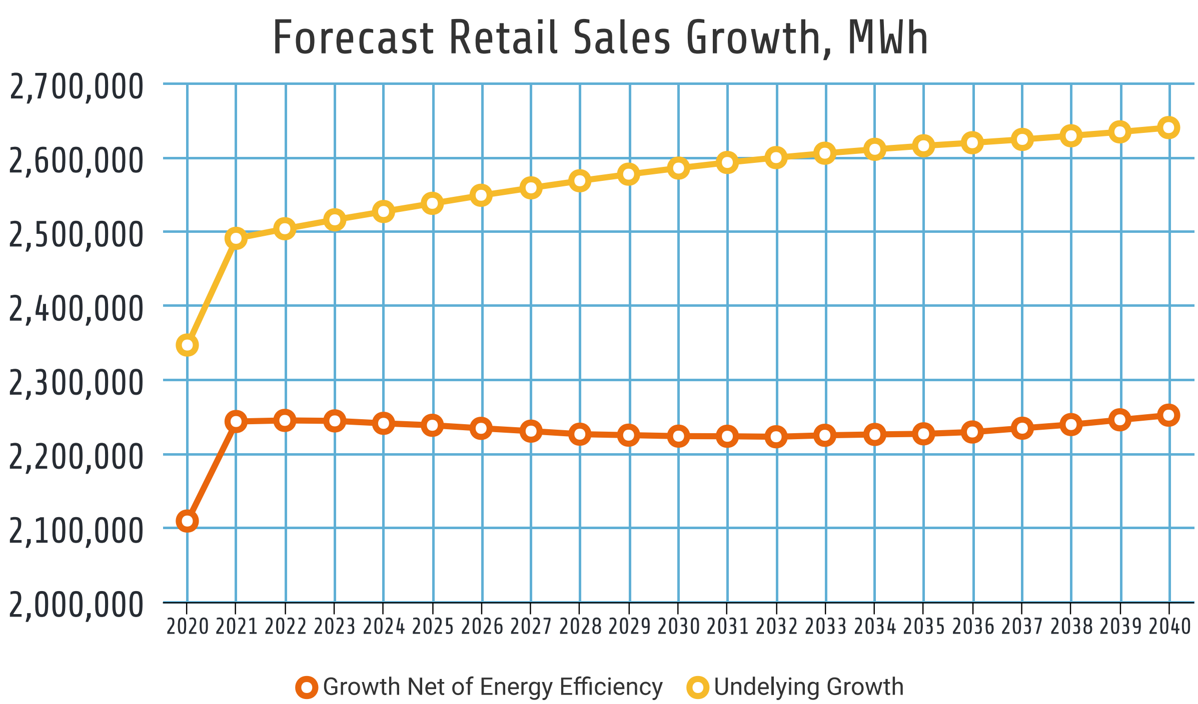
The BWL uses a modified multiple regression model to forecast electric energy demand and annual peak demands by its customers over the next twenty years. BWL has used this statistical method to prepare forecasts for its residential and commercial customers, who combined account for about 78% of the BWL's electric energy demand. For its industrial demand forecast, the BWL bases its forecast on a consensus of its planning staff. This is necessary because the Lansing area's industrial base is comparatively narrow and does not lend itself to statistical modeling. For its "other" customers, chiefly street lighting, the BWL uses historical data since this demand is dependent on night hours.

Once the forecast is developed, the BWL will make modifications for likely changes that have not been fully captured in the historical data. For example, the adoption of electric vehicles will likely grow in the coming years but would not have been captured in the historical data on which the statistical models are based. Likewise, distributed generation is likely to grow in the future. The BWL used studies prepared by consulting firms Siemens and GDS to estimate the impacts of electric/hybrid vehicles and distributed generation in future years and have incorporated the changes in this IRP. The electric vehicle energy requirements have been used to adjust the forecast while distributed generation impacts are included in available future generation.

Since the future cannot be known with certainty, the actual future demand for electricity will likely be different than the forecast. To capture this uncertainty, the forecast models produce expected future energy consumption along with a distribution of possible customer demands based on probability. The BWL uses these probability distributions to gauge the sensitivity of each strategy to the uncertainty around the forecast.

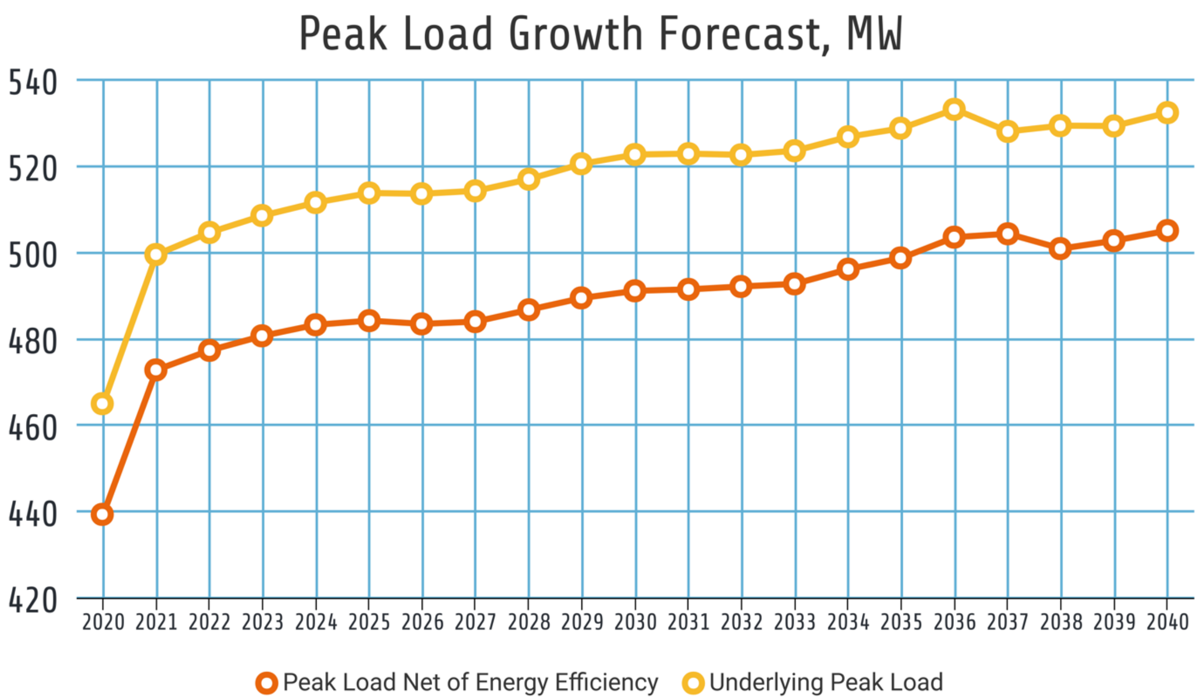
Figure 10 below represents the BWL underlying energy forecast prior to removing the effects of energy waste reduction savings along with the “net” forecast reflecting sales after removing the effects of energy waste reduction programs.

*Figure 10: Energy Demand Forecast*




For generation reliability planning, it is also necessary to forecast peak demand growth over the twenty-year planning horizon. This is done to meet the reliability standards that will be discussed in following sections. Like the energy forecast, the peak demand forecast graph shows both the underlying forecast and the forecast with the effects of legacy—not future—energy waste reduction programs’ peak demand impacts removed. These forecasts can be seen in Figure 11.

*Figure 11: Peak Demand Forecast*




The peak demand forecast serves as the basis for forecasting the BWL's future, mandatory, electric generating capacity requirements.[6]

## Measuring Available Generating Capacity

The BWL is part of the nation's bulk power system[7]. This requires the BWL to adhere to mandatory reliability standards promulgated by the National Electric Reliability Corporation and enforced by the Federal Energy Regulatory Commission. One of these standards requires the BWL to own or control enough electric generating capacity to meet its expected peak load and an additional amount, 8.9% above its expected peak, as a reserve margin. This reserve percentage is determined by the regions electric reliability coordinator, the Midcontinent Independent System Operator (MISO).

Each year, the BWL must demonstrate that it owns or controls sufficient generating capacity to meet this reliability standard. Measurement of an electric generating unit's generating capacity depends on its generating technology. For thermal units, like coal or natural gas, the utility must annually test the unit to demonstrate its generating capacity. The demonstrated capacity is then reduced by an amount that is based on its historical forced outage rate and the result is referred to as the units unforced capacity or

[6] Mandatory reliability standards have been authorized by the Energy Policy Act of 2005, PUBLIC LAW 109–58—AUG. 8, 2005
[7] The National Electric Reliability Corporation defines the bulk power system as all Transmission Elements operated at 100 kV or higher and Real Power and Reactive Power resources connected at 100 kV or higher. This does not include facilities used in the local distribution of electric energy.

UCAP. The generator receives capacity credit for how often it is operating or available to operate - its UCAP quantity.

The capacity credit assigned to intermittent electric generators like wind and solar installations is calculated differently. This is because these generators cannot be dispatched to generate electricity if the sun is not shinning or wind not blowing. Since the purpose of the reliability standards is to assure that sufficient capacity is available to meet customer demand, especially during peak periods, intermittent resources may or may not be available when needed or may be operating at an output less than their installed capacity value. However, based on historical experience, it is possible to calculate the probability that renewable facilities will contribute to meeting peak load needs. To do this, MISO calculates the "Effective Load Carrying Capacity" of wind installations[8]. MISO calculates and posts the default values of capacity credits for intermittent resources annually. For the 2020/2021 planning year, MISO calculated a 16.6% capacity credit for wind. This means that a 100 MW wind farm would receive 16.6 MW of capacity credit toward meeting the required reliability standard.

For solar facilities, MISO uses a first-year default 50% credit calculation. This is set to reflect its system average solar performance during peak periods. For example, a 100 MW solar facility's first year capacity credit would be 50 MW's. In subsequent years, the facility's capacity credit may be modified to reflect the facility's actual generation during MISO peak load.

If a utility does not own or control sufficient capacity to meet its capacity requirement, that is projected peak load plus an 8.9% reserve on a UCAP basis, it must purchase the capacity credit from other utilities that may have excess capacity credits. This capacity credit requirement has an impact on the economics of the various generating options.

## Existing BWL Generating Assets

Table 2 records the BWL's expected 2020 generating assets along with their name plate and UCAP generating capacities. The Eckert station is scheduled to be retired December 31, 2020 and Erickson on December 31, 2025. The Belle River generating station is scheduled to be retired in 2029-2030 period. The BWL has a purchase power agreement (PPA) with the Michigan Public Power Association (MPPA) for the capacity and energy from the Belle River generating plant.[9] The Granger EDL landfill gas PPA is scheduled to terminate December 31, 2020. Assembly solar is expected to begin partial operation at the end of 2020 and be fully operational in 2021. Pegasus wind is expected to have 68 MW of capacity when fully operational at the end of 2020. [10]

[8] MISO defines Effective Load Carrying capacity as the amount of incremental load a resource, such as wind, can dependably and reliably serve, while also considering the probabilistic nature of generation shortfalls and random forced outages as driving factors to load not being served.

[9] DTE Energy is the majority owners of Belle River and MPPA owns approximately 18% of the plant's capacity.

[10] Pegasus is expected to have 68 MW of installed capacity although 89 MW was used in the modeling program.

*Table 2: BWL 2020 Generating Resources*

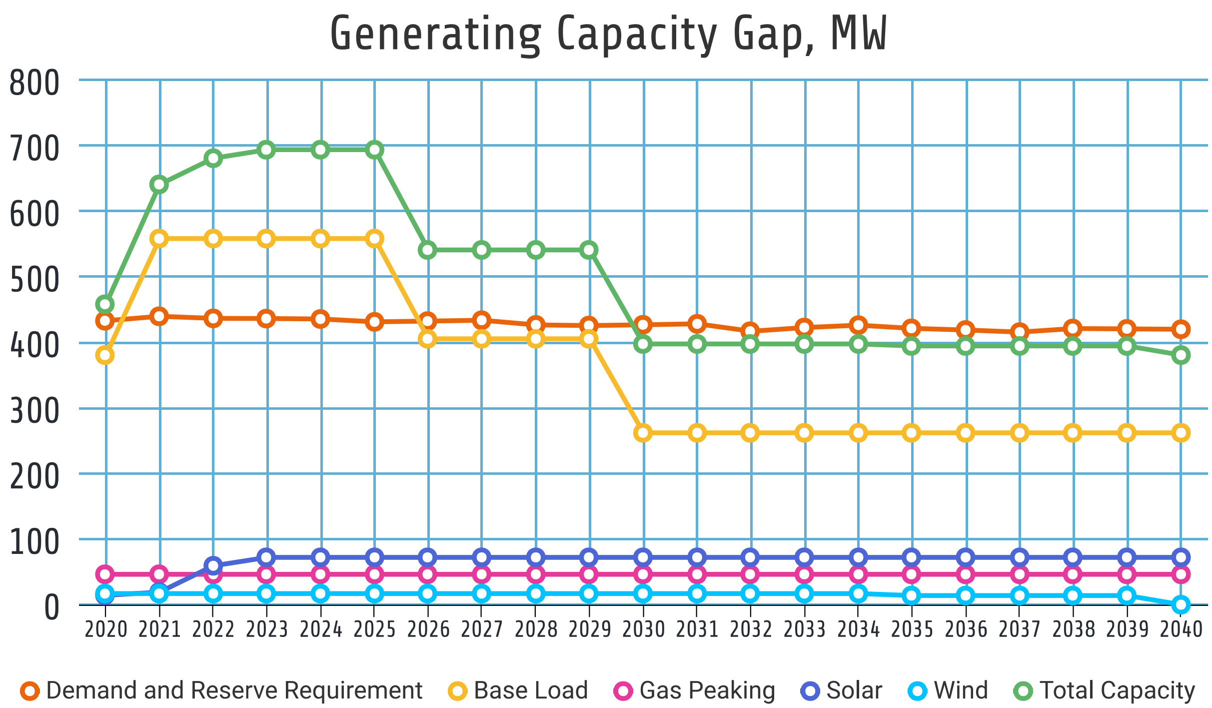
| Name | System | Fuel | Capacity[1] | Capacity Credit |
|---|---|---|---|---|
| REO Town Headquarters and Cogeneration Plant | Cogeneration | Natural Gas | 100 MW | 84.5 MW |
| Erickson Station | Electric | Coal | 155 MW | 152.8 MW |
| Eckert Power Station | Electric | Coal | 192 MW | 0 MW |
| Belle River Plant | Electric | Coal | 151 MW | 143.2 MW |
| Delta Energy Park | Renewable | Natural Gas | 55 MW | 46.3 MW |
| Beebe | Renewable | Wind | 19 MW | 3 MW |
| Assembly Solar | Renewable | Solar | 10 MW | 5 MW |
| BWL Owned & Community Solar | Renewable | Solar | 1 MW | 0.5 MW |
| Delta Solar | Renewable | Solar | 24 MW | 14.3 MW |
| Pegasus | Renewable | Wind | 68 MW | 11.3 MW |

## Capacity Requirements and Availability

The BWL's expected capacity credit towards its 2020 Planning Reserve Margin requirement is 461 MW without the capacity from Eckert. The expected requirement is 461 MW's meaning the BWL expects to have enough capacity credit to cover its requirement. As more renewable energy comes online and the Delta Energy Park comes into service in 2021, the BWL expects to have sufficient capacity credit to easily meet its requirements. After Belle River's retirement, however this this situation reveres and a capacity gap will occur. Figure 12 shows the forecast capacity requirements and availability based on current retirement schedules and the effects of reference case future load modifying resources on demand and reserve requirements.[11]

[11] Generating capacity is based on unforced outage capacity and MISO default values for wind and solar facilities.

*Figure 12: Generation Capacity Gap*




The reference case indicates that with its current, 2020, and expected generation assets, the BWL will not need additional generating assets until 2030. However, not all existing generating resources may be available over the coming years, or not all may be economic and part of a least cost plan, especially with changes occurring in the electric utility industry. For example, the growth of low marginal cost renewable energy and efficient, new natural gas generation have contributed to low energy costs. The lower energy costs have caused older less efficient coal units to be less competitive and have reduced or eliminated their operating margins. With higher fixed costs, these older units may no longer be a part of a least cost generation plan. To help determine whether these older units remain part of a least cost plan and whether the current generating portfolio best meets the IRP planning goals, this IRP used two resource sensitivities that retired the Erickson plant in 2021, four years earlier than the reference case.

## Resource Options

For modeling the strategies, the BWL included a broad range of resource options. Utility sited options included utility scale wind and solar, thermal units, 4 natural gas fueled combustion turbine units, 3 natural gas reciprocating generators, and battery storage. Demand-side options included energy waste reduction programming through the BWL's Hometown Energy Savers program, demand response programs aimed a peak load reduction, distributed generation options, and combined heat and power options. Included in this IRP is an estimate for electric/hybrid vehicle demand, since this may affect the long-term energy and demand forecasts. Table 3 below records existing options included in this IRP or facilities under contract scheduled to begin commercial operation (COD) within the next couple of years. Each of the units in Table 3 will provide generating capacity, energy, and, where appropriate, renewable energy credits. The data includes production technology, fuel source, and generating technology. Information on unit cost is included in Appendix D. Table 4 includes the information for new generating options examined in the IRP and used to model the scenarios and sensitivities.

*Table 3: Existing Generating Resources*

| Generation Option | Fuel | Capacity (MW) | Technology |
|---|---|---|---|
| Belle River | Coal | 150 | **Steam Boiler** |
| Erickson | Coal | 159 | **Steam Boiler** |
| REO Town | Natural Gas | 84.5 Summer<br>109 Winter | **Combined Cycle Cogeneration** |
| Delta Energy Park | Natural Gas | 178 Summer<br>203 Winter | **Combined Cycle** |
| Delta Energy Park | Natural Gas | 46 Summer<br>57 Winter | **Combustion Turbine** |
| Delta Solar | | 24 | **PV** |
| Ranger Solar<br>2021 COD | | 80 | **PV** |
| Invenergy Solar<br>2022 COD | | 10 | **PV** |
| NextEra Solar<br>2020 COD | | 25 | **PV** |
| Beebe<br>Wind | | 19 | **Wind Turbine** |
| Pegasus Wind<br>2020 COD | | 89 | **Wind Turbine** |

*Table 4: New Generating Options*

| New Generation Option | Fuel | Capacity (MW) |
|---|---|---|
| Combustion Turbine | Natural Gas | 7 |
| Combustion Turbine | Natural Gas | 10 |
| Combustion Turbine | Natural Gas | 20 |
| Combustion Turbine | Natural Gas | 44 |
| Reciprocating Internal Combustion | Natural Gas | 3.3 |

| | | |
|---|---|---|
| Reciprocating Internal Combustion | Natural Gas | 9.3 |
| Solar | PV | 5 Scalable |
| Solar | PV | 10 Scalable |
| Solar | PV | 20 Scalable |
| Wind | Wind | |
| Battery Storage | External Energy Source | 25 MWh in 1, 2 and 4-hour Options |

The consulting firm GDS was retained to prepare estimates for energy waste reduction, load management (demand response), and combined heat and power potential in the BWL's service territory. Collectively these options were estimated as an integrated demand side management study. Siemens Corporation provided an estimate of electric/hybrid vehicle penetration and associated future electricity demand and an estimate of future solar distributed generation adoption for this IRP.

## Energy Waste Reduction

Michigan Public Act 295 of 2008 adopted requirements for all load serving utilities in Michigan to undertake energy waste reduction and renewable energy programs. The energy waste reduction standard adopted by the State requires utilities to plan and undertake programs that save 1% of each utility's retail sales annually. Every two years, Michigan utilities must submit plans detailing how they intend to achieve the standard in the coming years. These plans must be approved by the Michigan Public Service Commission (MPSC). Each utility must also submit evaluations demonstrating that they achieved the standard annually to the MPSC.

The BWL has consistently exceeded the State standard. After 2021, the State planning, reporting, and program enforcement requirements will no longer apply to municipal utilities like the BWL. However, the BWL has been and remains committed to assisting customers with cost effective electric energy savings. BWL customers have also expressed strong support for energy waste reduction programs. This IRP includes 5 separate "bins", or annual quantities, of energy waste reduction for inclusion in the modeling program.

For most energy waste reduction programming, one or more cost effectiveness tests are applied. There are some programs, like low income and pilot programs for which cost effectiveness is not required. Other programs must demonstrate that they are cost effective to be incorporated into the Hometown Energy Savers program. Appendix B includes a discussion of energy waste reduction cost effectiveness tests.

Michigan PA 295 adopted a Utility Cost test (UTC) as the measure of cost effectiveness for energy waste reduction programs. This test uses a narrow definition of costs. While most states make use of multiple tests to gain a more comprehensive appraisal of the costs and benefits of energy waste reduction programs, the Total Resource Cost (TRC) test is the predominant test relied on nationwide. The BWL requested that GDS use the TRC and the UTC to evaluate potential energy waste reduction in its service territory. However, it requested GDS to use the TRC as the primary test in estimating potential energy waste reduction savings available over the planning horizon.

GDS included a total of 547 different energy waste reduction measures in its BWL potential study. Many are included in the Michigan Energy Measure Databases (MEMD) and others from GDS's own databases and still others from other jurisdictions. Applying these measures required many permutations for different building types, replacement assumptions, and efficiency levels. In total, 4,171 measure permutations were utilized for the BWL study. Approximately 56% of the measures passed the TRC benefit cost test with a ratio of 1.0 or greater.

The GDS study provided estimates for three customer classes: residential, commercial, and industrial. Estimates of cost-effective savings were made for a ten-year period 2021 through 2030, inclusive, and an additional 10 years, 2031 through 2040. Because the BWL has a small, compact service territory, limited load information, and the service territory's energy end-use stock, GDS utilized data from several sources to estimate the BWL's energy waste reduction potential. Data from U.S. Department of Energy surveys, energy end-use saturation studies from other Michigan utilities, Michigan Public Service Commission surveys, and other data sources were used in the GDS study. A complete description of the estimation process and data sources is included in Appendix B.[12]

## Energy Waste Reduction Potential Results

Estimating the amount of energy waste reduction in the future begins with the technical potential for electric energy reduction. Technical potential is the amount of savings available if all non-efficient electric consuming devices were replaced by efficient devices, regardless if cost effective and achievable or not.

Not all technical potential is cost effective. Therefore, estimates of future energy waste reductions include the economic potential, which measures the amount of technical potential savings available that is cost effective. However, not all energy waste reduction that is economic is achievable because of various barriers.

Achievable potential represents the economic potential that could reasonably be expected to be realized. Barriers like customer preferences, lack of information, or lack of money to participate in energy waste reduction programs results in not all economic savings being realized.

Table 5 below compares the estimated potential electricity savings based upon various BWL incentives over the next 10 years and using the TRC cost effectiveness test, while the twenty-year energy waste reduction estimates are shown in table 6. The figure presents estimated, cumulative, potential savings as a percent of the BWL's retail sales forecast and in megawatt hours based on various incentive levels. The

[12] While this data is very useful for estimating the BWL's energy waster reduction potential, the reader should bear in mind that the BWL's retail sales is far more concentrated in the commercial sector than most other Michigan utilities.

three righthand columns represent achievable potential. 100% TRC assumes that the BWL will provide an incentive equal to 100% of the incremental cost of the most efficient end use over a standard (code compliant) end use. 50% assumes an incentive equal to half the incremental cost of the most energy efficient end use over a standard energy end use device. Most BWL Hometown Energy Savers programs are based on the 50% incentive level. And PB TRC assumes an incentive level sufficient to "buy down" the payback on a most efficient end use to 5 years. Incentive levels are important because they are used to determine estimated customer adoption rates of energy efficiency measures and the resulting energy savings.

*Table 5: 10 Year Energy Waste Reduction Potential*

| ***Electric MWh Savings as % of Sales Forecast*** | **Technical** | **Economic** | **100% TRC** | **50% TRC** | **PB TRC** |
|---|---|---|---|---|---|
| *Savings % - Residential* | 33.8% | 20.6% | 11.3% | 8.3% | 10.2% |
| *Savings % - Commercial* | 40.5% | 21.5% | 15.3% | 12.0% | 9.1% |
| *Savings % - Industrial* | 30.3% | 19.3% | 14.1% | 10.3% | 9.6% |
| *Savings % - Total* | 37.0% | 20.9% | 14.0% | 10.7% | 9.5% |
| ***Electric MWh Savings*** | | | | | |
| *Savings MWh - Residential* | 207,131 | 126,057 | 69,362 | 50,945 | 62,563 |
| *Savings MWh - Commercial* | 513,773 | 272,824 | 194,260 | 151,663 | 115,365 |
| *Savings MWh - Industrial* | 108,704 | 69,442 | 50,615 | 36,910 | 34,466 |
| *Savings MWh - Total* | 829,607 | 468,323 | 314,237 | 239,517 | 212,394 |
| ***Electric Summer Peak Savings*** | | | | | |
| *Savings MW - Residential* | 44 | 19 | 11 | 8 | 9 |
| *Savings MW - Commercial* | 104 | 45 | 31 | 21 | 18 |
| *Savings MW - Industrial* | 20 | 13 | 9 | 7 | 6 |
| *Savings MW - Total* | 168 | 77 | 51 | 36 | 34 |

*Table 6: 20-Year Energy Waste Reduction Potential*

| ***Electric MWh Savings as % of Sales Forecast*** | Technical | Economic | 100% TRC | 50% TRC | PB TRC |
|---|---|---|---|---|---|
| *Savings % - Residential* | 34.7% | 18.5% | 14.4% | 10.1% | 12.6% |
| *Savings % - Commercial* | 48.8% | 27.4% | 21.3% | 16.8% | 12.9% |
| *Savings % - Industrial* | 34.9% | 21.7% | 16.1% | 13.2% | 12.4% |
| *Savings % - Total* | 42.8% | 24.1% | 18.6% | 14.4% | 12.8% |
| ***Electric MWh Savings*** | | | | | |
| *Savings MWh - Residential* | 220,078 | 117,119 | 91,364 | 63,822 | 80,167 |
| *Savings MWh - Commercial* | 632,186 | 355,291 | 275,642 | 217,873 | 167,216 |
| *Savings MWh - Industrial* | 124,338 | 77,147 | 57,191 | 46,919 | 44,012 |
| *Savings MWh - Total* | 976,602 | 549,557 | 424,198 | 328,614 | 291,395 |
| ***Electric Summer Peak Savings*** | | | | | |
| *Savings MW - Residential* | 55 | 20 | 16 | 12 | 13 |
| *Savings MW - Commercial* | 128 | 59 | 45 | 32 | 26 |
| *Savings MW - Industrial* | 23 | 14 | 10 | 9 | 8 |
| *Savings MW - Total* | 206 | 93 | 72 | 52 | 47 |

Comparing the various estimates of potential waste reduction over the next 10 years, the figure reveals that 37% is technically available, or 3.7% per year, but only 20.9% is cost effective based on the TRC, or 2.09% annually. It also indicates that 14% is achievable if the BWL provides incentives equal to 100% of the increased cost of the most energy efficient appliances and lights over the non-efficient appliances and lights. That amount of achievable savings falls to 10.7% over the 10-year period if the BWL incentives are equal to 50% and falls to 9.5% over the 10 years, 2021-2030 if the BWL provides incentives that yield a 5-year customer payback on energy efficient devices.

The tables also include the estimated potential on-peak capacity reductions that the energy waste reduction programs are expected to provide for each period and for each incentive level.

The results of the GDS study, both the amount of energy that could be cost-effectively saved and the costs of the programs for the residential, commercial, and industrial customer classes are included as Appendix B. GDS estimated the potential for saved energy for each year over the period 2021 to 2041. These estimates were used to create 5 “Bins” of energy waste reduction measures. The Bins were included with other resource options and used to model the strategies.

The 5 energy waste reduction bins have been created from cost effectiveness tests of the measures included by GDS. Table X describes the five energy waste reduction Bins. A more thorough discussion is included in Appendix B.

*Table 6: Energy Waste Reduction Bins*

| Bin Number | Energy Waste Reduction Included |
|---|---|
| 1 | Measures with a TRC score equal to or greater than 2 |
| 2 | Measures not in Bin 1 but with a TRC score equal to or greater than 1 |
| 3 | Measures not in Bins 1 & 2 but with a UTC score equal to or greater than 1 and a TRC score equal to or greater than .8 |
| 4 | Measures that are not in Bins 1, 2, &3 but pass the UTC score equal to or more than 1 with higher avoided cost |
| 5 | Measures not in Bins 1, 2, 3 & 4 but with a UTC score equal to or greater than 1 |

The 5 Bins were created to provide a "supply curve "of energy waste reduction measures. Previous IRP models used energy waste reduction as a binary input, either fixed as a resource with a fixed quantity or not included. With creation of the five Bins, this IRP is using energy waste reduction similarly to the balance of other resource options. This provides a clearer picture of the cost effectiveness of energy waste reduction programs as a component of a larger energy resource portfolio. This also allows planners to test the relationship between energy waste reduction and lower forecast avoided energy costs associated with the growth of "zero or lower marginal cost" energy production from renewable energy generators.

The GDS study projects that the energy waste reduction potential declines after mid-2020's due to two major factors. First, with the forecast increase in renewable energy in this region, avoided energy costs are projected to decline slowly over the next 20 years. This serves to undermine the cost-effectiveness of energy waste reduction investment even as capacity credit values are expected to rise. Energy waste reduction measures are principally intended to save energy; they save capacity only secondarily.

Second, the declining cost-effectiveness is due to presumed saturation in the Lansing area of energy saving measures. Unlike renewable energy options, which are assumed to improve through technical advances, no such assumptions have been made for energy efficiency measures. This assumption freezes energy efficiency technology at the current level and implies no new, efficient options in future years. This would seem to be a shortcoming that will need to be addressed in subsequent IRPs.

An important attribute of energy waste reduction programs not captured in cost effectiveness tests is their ability to displace both thermal and renewable energy investment. These investments are long-term fixed cost commitments. Over a longer time-period, managing these commitments offers some financial and operating flexibility to the BWL but this attribute is difficult to incorporate into a cost benefit test.

To gauge customers' opinions regarding important energy planning issues, the BWL commissioned a survey of its customers. In total 300 business and 400 residential customers were surveyed. The responses demonstrated strong support for BWL promotion of energy waste reduction programs. 87% of residential and 90% of business customers were either somewhat or strongly supportive of the BWL providing financial incentives for customers' energy waste reduction investments. With strong customer support for these programs, the BWL has incorporated energy waste reduction options in its modeling through the 5 bins used with the strategies and in the resource sensitivities.

## Demand Response

Demand response (DR), also referred to as load management, are programs that are designed to reduce customers use of electricity for short periods of time during peak hours. Some DR programs are based on rate differential like time of use or peak load pricing. These types of programs charge more for electricity consumptions during peak periods, like hot summer afternoons, and less during off-peak periods. Other programs allow the BWL to either request or control customer energy using equipment like air conditioners. The customer's appliance or electricity using device is interrupted to reduce peak demand for electricity[13]. The programs are usually voluntary, interruptions are usually brief, and the customers receives a rate reduction for participation in the program.

GDS examined several DR programs for both residential and nonresidential customers. For residential customers, GDS included direct load control programs, like interruptible air conditioning or interruptible electric water heaters. They also included rate incentives like time of use and peak load pricing. In anticipation of growing demand for electric vehicles, they also included an electric vehicle charging rate.

For the nonresidential customers, GDS examined interruptible rates, direct load control programs, time of use and peak load pricing, thermal energy storage, and automated load management options.

GDS again began with technical potential peak load reductions possible with these programs and then reduced the potential for economic and achievable savings. To estimate the economic and achievable savings, GDS used the TRC and the UTC. In addition, GDS also provided the Participant Test (PCT) and the Ratepayer Impact Measure (RIM). The key tests, TRC and UTC, measure the benefit of the program to the utility as the demand and energy costs avoided because of the program. The benefit to the customer is measured by the customer's bill saving and any incentive provided by the utility. The cost is measured as the BWL's cost to purchase, install, and operate the equipment necessary to operate the program and the administrative cost of the program.

Because the BWL's avoided costs are comparatively low, most of the demand response programs did not pass the cost effectiveness tests. To pass the cost effectiveness test, the program would need a benefit/cost ratio of one or greater. Table 7 below shows the technical, economic, and achievable results for both the residential and nonresidential customer along with the results of the benefit cost tests.

[13] Interruptions are usually brief, lasting 15 to 20 minutes for residential customers.

*Table 7: Demand Response Potential*

| - | TRC Ratio | UCT Ratio | PCT Ratio | RIM Ratio |
|---|---|---|---|---|
| *DLC Central AC Switch* | 0.12 | 0.12 | N/A | 0.12 |
| *DLC Room AC* | 0.07 | 0.07 | N/A | 0.07 |
| *DLC Pool Pumps* | 0.10 | 0.10 | N/A | 0.10 |
| *DLC Water Heating* | 0.05 | 0.05 | N/A | 0.05 |
| *DLC Central AC Thermostat* | 0.10 | 0.15 | 1.07 | 0.15 |
| *Electric Vehicle Charging Rate* | 0.12 | 0.31 | 0.00 | 0.15 |
| *Time of Use with Enabling Technology* | 0.15 | 0.15 | N/A | 0.06 |
| *Time of Use without Enabling Technology* | 0.53 | 0.53 | N/A | 0.22 |
| *Critical Peak Pricing with Enabling Technology* | 0.25 | 0.25 | N/A | 0.25 |
| *Critical Peak Pricing without Enabling Technology* | 0.67 | 0.67 | N/A | 0.64 |
| *DLC Central AC Switch* | 0.13 | 0.13 | N/A | 0.13 |
| *DLC Central AC Thermostat* | 0.12 | 0.13 | 1.89 | 0.13 |
| *Interruptible Rate* | 0.03 | 0.03 | N/A | 0.03 |
| *DLC Water Heating* | 0.04 | 0.04 | N/A | 0.04 |
| *Thermal Electric Storage Cooling Rate* | 0.03 | 0.12 | 0.02 | 0.09 |
| *DLC Lighting* | 0.01 | 0.01 | N/A | 0.01 |
| *Auto Demand Response - AC* | 0.11 | 0.13 | 0.00 | 0.12 |
| *Auto Demand Response - Lighting* | 0.05 | 0.05 | 0.21 | 0.05 |
| *Time of Use with Enabling Technology* | 0.21 | 0.21 | N/A | 0.08 |
| *Time of Use without Enabling Technology* | 0.19 | 0.19 | N/A | 0.08 |
| *Critical Peak Pricing with Enabling Technology* | 1.04 | 1.04 | N/A | 1.01 |
| *Critical Peak Pricing without Enabling Technology* | 0.55 | 0.55 | N/A | 0.52 |

Total estimated demand reduction for technical, economic, and achievable potential is shown in table 8.

*Table 8: Demand Reduction Forecast*

| | 2025 Potential (MW) | 2030 Potential (MW) | 2035 Potential (MW) | 2040 Potential (MW) |
|---|---|---|---|---|
| *Technical* | 136 | 137 | 138 | 138 |
| *Economic* | 48 | 48 | 48 | 49 |
| *Achievable* | 11 | 12 | 12 | 12 |

The potential study resulted in a 12 MW reduction in peak demand in 2030, and this was included in the IRP modeling.

## Distributed Generation

Distributed generation options are technologies that are sited at customer premises. Two well-known options are combined heat and power (CHP) and customer owned solar energy installations. Customer owned solar can be either residential customers who install solar panels on their homes or commercial and industrial customers with solar totally or partially offsetting their electricity consumption. The BWL used estimates of distributed generation penetration in the BWL's service territory prepared by Siemens Corporation. These options can reduce the need for future utility owned generation.

## Distributed Solar Potential

To project the future penetration of distributed solar (DS), Siemens used a bass-diffusion model. Bass-diffusion models are widely used to estimate the market for new products and services. Siemens has developed a proprietary DS penetration model based on the methodology described in National Renewable Energy Laboratory (NREL) SolarDS[14] and DGen[15] model documentation. In the Siemens' model, the adoption rates and the maximum market penetration are a function of the customer's payback period, thus the adoption rate is assumed to be based on economics alone. The payback period is based on the down-payment (equity portion), federal tax credits in the form of the Investment Tax Credit (ITC) through 2022[16], any incentives provided by the BWL and the net benefits accruing to the business or homeowner.

Siemens produced three estimates for the residential and three for the commercial distributed generation market for the period running from 2021 to 2040. These were low, reference, and high penetration cases. The three cases were based on NREL's high cost, low cost, and reference cost estimates for solar installation costs over the period ending with 2050 from its 2019 Annual Technology Baseline report. It also used data from the BWL's net metering program.

[14] https://www.nrel.gov/docs/fy10osti/45832.pdf
[15] https://www.nrel.gov/analysis/dgen/
[16] https://www.irs.gov/pub/irs-drop/n-18-59.pdf

Siemens compared the model estimates to the actual historical experience of the BWL's net metering program. While the commercial adoption estimates were in line with the BWL's experience, actual residential installations were higher than the Siemens' estimates. Table 9 records the BWL program experience and the Siemens' estimate of distributed generation for both customer classes over the planning horizon.

*Table 9: Forecast Distributed Generation Adoption*

| | Commercial | | | | Residential | | | |
|---|---|---|---|---|---|---|---|---|
| | Program | Low | Ref. | High | Program | Low | Ref. | High |
| *2010* | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| *2011* | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| *2012* | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| *2013* | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 0 |
| *2014* | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 |
| *2015* | 1 | 1 | 2 | 2 | 7 | 0 | 0 | 0 |
| *2016* | 2 | 1 | 2 | 2 | 11 | 0 | 0 | 0 |
| *2017* | 2 | 2 | 3 | 3 | 14 | 0 | 0 | 0 |
| *2018* | 0 | 2 | 3 | 3 | 23 | 0 | 0 | 0 |
| *2019* | 4 | 2 | 4 | 4 | 44 | 0 | 0 | 0 |
| *2020* | - | 2 | 5 | 7 | - | 0 | 1 | 3 |
| *2021* | - | 3 | 5 | 9 | - | 0 | 1 | 3 |
| *2022* | - | 3 | 6 | 15 | - | 0 | 2 | 13 |
| *2023* | - | 4 | 8 | 19 | - | 0 | 3 | 16 |
| *2024* | - | 5 | 9 | 23 | - | 0 | 3 | 20 |
| *2025* | - | 6 | 12 | 28 | - | 0 | 4 | 25 |
| *2026* | - | 8 | 14 | 35 | - | 0 | 5 | 30 |
| *2027* | - | 10 | 17 | 43 | - | 0 | 6 | 37 |
| *2028* | - | 12 | 21 | 52 | - | 0 | 7 | 45 |
| *2029* | - | 14 | 26 | 64 | - | 0 | 9 | 55 |
| *2030* | - | 18 | 32 | 79 | - | 0 | 11 | 67 |
| *2031* | - | 53 | 53 | 129 | - | 149 | 149 | 669 |
| *2032* | - | 64 | 64 | 158 | - | 182 | 182 | 814 |
| *2033* | - | 78 | 78 | 192 | - | 220 | 220 | 988 |
| *2034* | - | 95 | 95 | 233 | - | 267 | 267 | 1198 |
| *2035* | - | 115 | 115 | 283 | - | 323 | 323 | 1449 |
| *2036* | - | 139 | 139 | 342 | - | 390 | 390 | 1749 |
| *2037* | - | 168 | 168 | 413 | - | 470 | 470 | 2106 |
| *2038* | - | 202 | 202 | 497 | - | 564 | 564 | 2528 |
| *2039* | - | 242 | 242 | 595 | - | 675 | 675 | 3024 |
| *2040* | - | 288 | 288 | 709 | - | 804 | 804 | 3603 |

Cost for solar installations has fallen substantially over the past ten years. This trend is likely to continue, albeit perhaps at a slower rate. Siemens has taken this into consideration in preparing its estimates. It should also be noted that when reviewing these estimates distributed generation adoption will be influenced by government policies. Michigan's recent policy of granting property tax relief to homeowners who install solar panels on their homes will help promote distributed generation for the residential class. However, the expiration of a 30% federal tax credit in 2022 will have the opposite effect and will likely slow adoption rates.

The estimates provided by Siemens have been incorporated into the IRP as available generation. Appendix B describes Siemens' method for estimating the adoption of distributed generation in the BWL's service territory.

## Combined Heat and Power (CHP)

Combined heat and power, also called cogeneration, is a process of producing electricity and steam, or heat, for another function, either for a production process or space conditioning. CHP installations can be found in both utility settings and, more commonly, on customer facilities. The BWL's REO Town cogeneration plant is an example of a utility CHP installation. Most, however, are found on customer premises.

As a high-level screening estimate, GDS relied on two studies to estimate BWL customers' potential for CHP. First it reviewed the Department of Energy's Technical Potential Study[17], which resulted in a 4,291 MW estimate for the State of Michigan. It also reviewed a Michigan Energy Office Estimate that resulted in a potential range of 722 to 1014 MW. [18] Calculating the BWL's sales to be 2.1% of Michigan retail electric sales, GDS arrived at a CHP potential range of 15.2 to 90.1 MW's for the BWL.

GDS developed cost and operating performance estimates for 25 CHP generation options, including both natural gas combustion turbines and reciprocating engines. To estimate the CHP potential, GDS used the TRC benefit cost test to screen the potential CHP technologies for the BWL service territory. As noted previously, the BWL's near term avoided costs are comparatively low. This low avoided cost resulted in no CHP technologies passing the TRC. As a result, GDS did not project BWL retail sales migrating to CHP over the planning horizon. Details of the study can be found in Appendix B.[19]

## Electric Vehicles

In addition to generating options, the BWL also sought to explore the possible impact on the growing interest in electric vehicles. Since electric vehicles charge their batteries from the BWL's distribution system, they may increase electric energy demand significantly. The timing of vehicle charging is of importance, since charging during on-peak hours could increase the need for more generating capacity. Currently, the BWL offers a rate that provides a rate reduction for off-peak charging later in the evening,

---

[17] U.S. Department of Energy, Combined Heat and Power (CHP) Technical Potential in the United States, Appendix A, March 2016, p.A-1

[18] Prepared for the Michigan Energy Office on behalf of the Michigan Agency for Energy and the US Department of Energy CHP, Road Map for Michigan, February 2018, p.7

[19] The BWL expects to continue studying CHP potential using a more comprehensive battery of benefit-cost tests in the next year.

which has been effective. However, as the market and use of electric vehicles grow it is likely that more of the charging time will be throughout the day, including peak periods.

Siemens Corporation was contracted to provide an estimate of electric vehicle adoption and electric energy and capacity impacts for this IRP. Electric vehicle charging serves to increase the demand for energy, and depending on when charging occurs, potentially the required electric generating capacity. Siemens has developed proprietary electric vehicle forecasting methods including a light duty vehicle (LDV) adoption tool, and proprietary analytical models to forecast both LDV and electric commercial vehicle and electric bus adoption rates.

For LDV reference case adoption rates, Siemens adjusted the customer choice MAT Model developed by Oak Ridge National Labs (ORNL) along with its own inputs. The ORNL model provides an estimate for the state of Michigan, which Siemens then adjusted to fit the BWL's service territory.

For commercial vehicles, Siemens created a reference case based on the Department of Energy's Annual Energy Outlook and relied on third party forecasts for bus adoption reference case.

After producing reference case estimates for electric and hybrid vehicle adoption in the BWL's service territory, Siemens established high and low adoption cases. For the low adoption case, Siemens used the Energy Information Agency's 2019 Annual Energy Outlook. For the high adoption forecast, Siemens used Bloomberg New Energy Finance Forecast. For converting vehicle adoption to demand for electricity on the BWL system, Siemens used filings from the California Public Utility Commissions case on charging infrastructure.[20]

Figure 13 shows the reference case forecast for cumulative electric and hybrid vehicle adoption in the BWL service territory, including LDV, commercial vehicles, and buses.

The resulting energy impacts of the low, high, and reference cases is shown in Figure 14.

[20] EIA AEO 2019; BNEF, Mass Transit Magazine; California Utilities Commission filings on charging infrastructure

*Figure 13: Electric Vehicle Adoption Forecast*

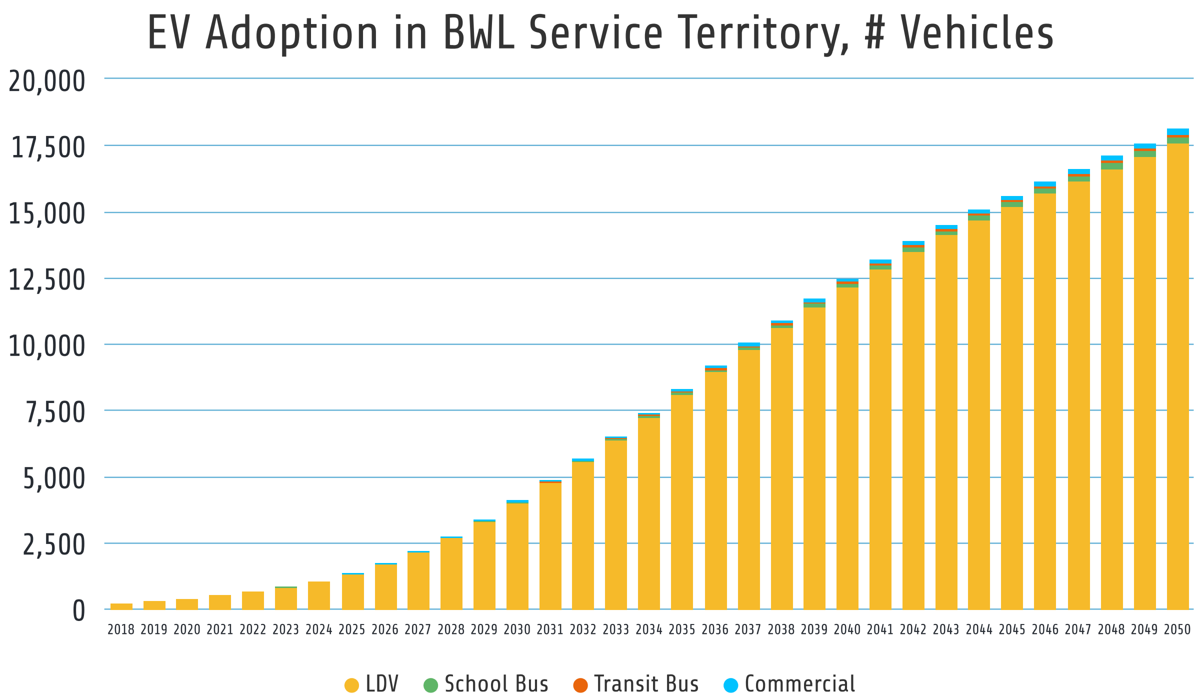
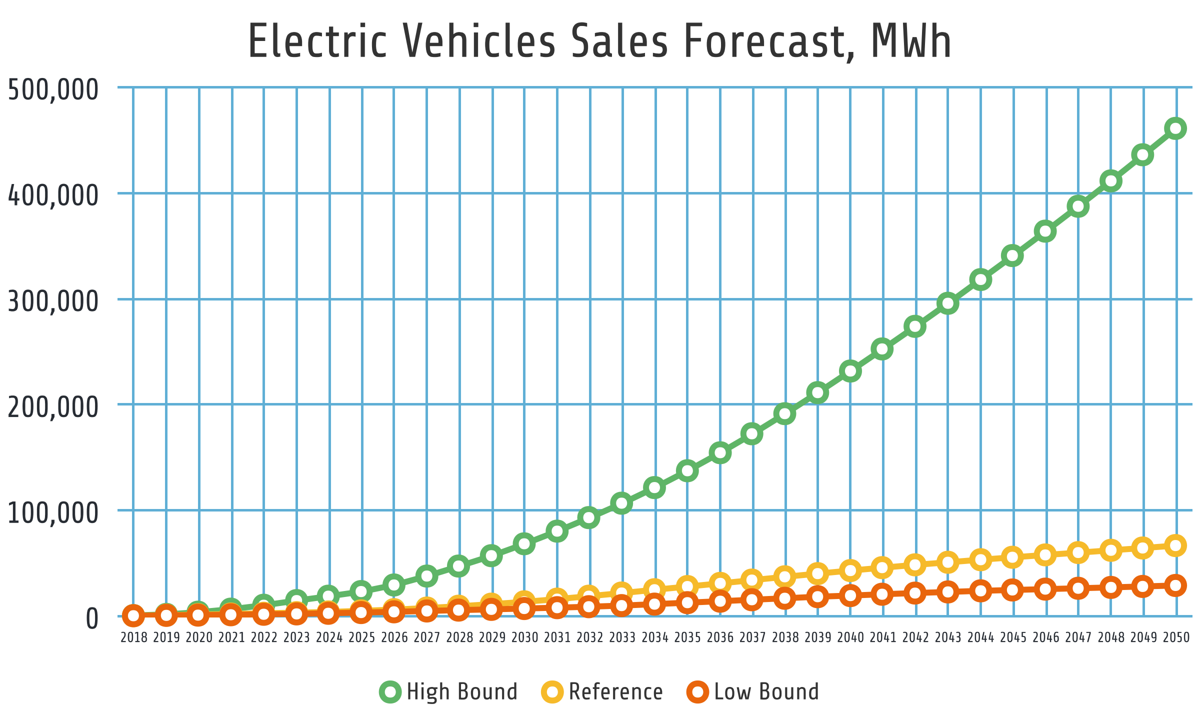
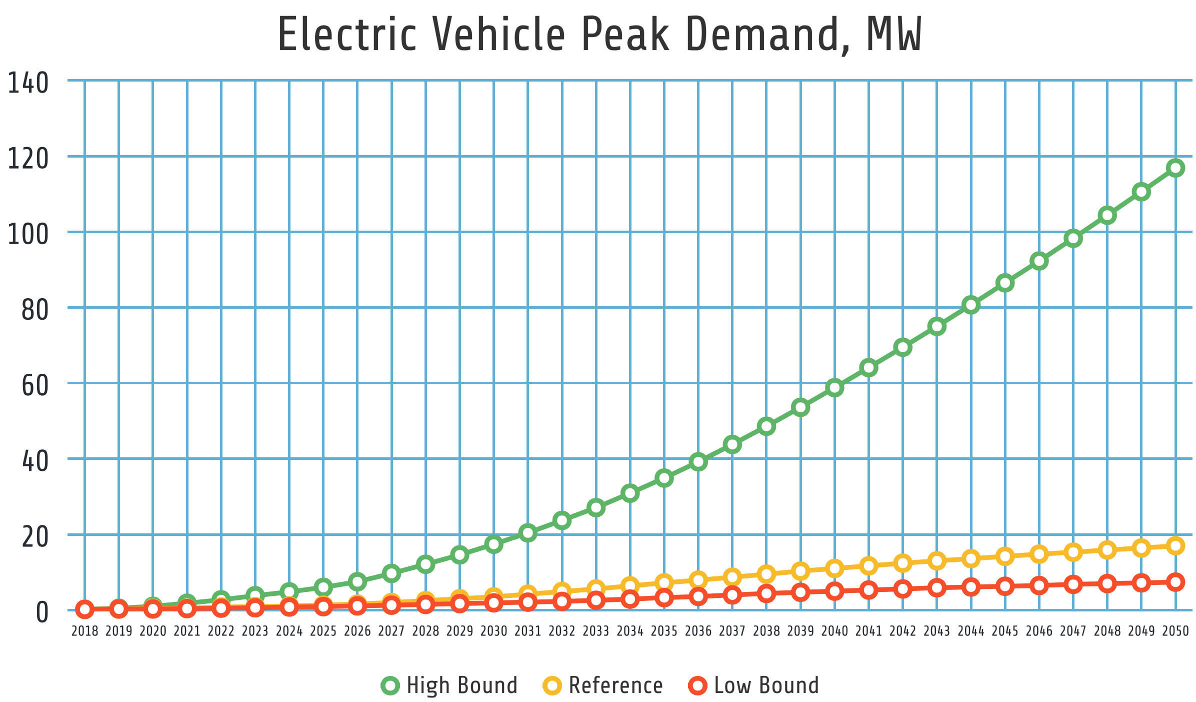



*Figure 14 Electric Vehicle Sales Forecast*



In addition to energy sales, peak demand can also be affected, depending on charging times. Siemens also provided an estimate of peak load impacts for each of the three cases. This information is shown in Figure 15.

*Figure 15: Electric Vehicle Peak Demand Forecast*




## Electric Transmission

Although the BWL owns its transmission system, like other utilities it finds using the interstate electric transmission grid to be a major benefit. Without the interstate grid, the cost of maintaining and operating a reliable electric system would be much higher. This requires the BWL to take transmission service form this region's interstate electric system operator – MISO.

There are two broad classes of electric transmission service available to electric utilities. Most utilities take "network" service. This service allows a utility to use the interstate transmission system to move power from any "source" to any "sink".[21] This service is limited only by the adverse financial impacts associated with moving power through congested transmission systems.

The second type of transmission service is referred to as "point to point" transmission service. This is service requires the user to identify the source and the sink of the service. Point to point transmission service is not as flexible as network service, but under some circumstances can be significantly less expensive.

[21] A source is a generating resource like a thermal generating unit, a solar installation, or a wind farm that injects power into the electric grid. A sink is a load node, or a facility serving electricity using customers who withdraw power from the grid.

Unlike most utilities in Michigan and this region of the country, the BWL has maintained control of its transmission system. Most utilities that own their transmission have turned over control of their systems to MISO. DTE Energy and Consumers Energy, Michigan's largest electric utilities, have sold their transmission assets to the International Transmission Company and the Michigan Electric Transmission Company respectively. These transmission companies in turn have given control of their transmission systems to MISO.

The BWL's policy of retaining control of its transmission system comes from its 1984 participation in the Michigan Public Power Agency's (MPPA) Belle River powerplant project. The participation involved a purchase power agreement between the BWL and MPPA for electric capacity and energy. It also included participation in transmission assets necessary to transmit power from Belle River to the MPPA members, including Lansing.

The Belle River transmission project has provided the BWL with 150 MW of firm point to point transmission capacity under favorable rates, referred to as "Grandfathered Agreements". The favorable rate has provided economic benefits and acted as an incentive for the BWL to remain a point to point transmission customer.

In addition to 150 MW of firm point to point service, the BWL has acquired 12 MW of network service through its participation in the MPPA. These agreements provide the BWL with 162 MW of firm transmission service from the interstate electric grid. This does not limit the BWL's ability to import more power from the interstate grid if necessary, but they do allow for electric transmission over the State grid at favorable rates.

The BWL's commercial transmission configuration provides a three-part electric transmission cost curve for modeling the strategies. The three parts arise from the BWL's MPPA related transmission entitlements.

Segment 1 - 150 MW

Segment 2 - 12 MW

Segment 3 - Transmission more than 162 MW but less than 400 MW

Each segment is priced differently with the Segment 1 being the least expensive and Segment 3 being the most expensive. The 400 MW of service creates a maximum electric energy import assumption for the IRP models, referred to as the transmission modeling constraint.

## IRP Modeling Program

Modeling is used to help evaluate the tradeoff between different electric generating options on future costs, operations, and environmental impacts. It is very useful in determining which set of renewable, thermal, demand response and customer options may best meet the core goals of affordability, reliability, and environmental stewardship. This is especially the case with growing customer interest in onsite generation and clean energy, advances in communications, and declining renewable costs among other changes.

For this IRP, the BWL has changed its modeling format. In previous IRP's the BWL relied on a deterministic model that had been widely used in the utility industry. Although deterministic models are still used in the industry, stochastic models offer some refinements in evaluating risks and the performance of intermittent renewable options, like wind and solar energy. The BWL has employed the Ascent stochastic model to directly incorporate uncertainty around future events.

Uncertainty and risk related to selected inputs of future customer demand, weather and renewable energy production, electricity market prices, and natural gas prices are incorporated as probability distributions. This provides BWL planners with a better picture of cost and risk tradeoffs of various resource portfolio options.

For each strategy and sensitivity, the stochastic model makes 100 random draws from probability distributions of each selected input and computes performance data and the cost of the portfolio over the planning horizon. This creates a distribution of 100 portfolio cost estimates and allows for estimation of a mean cost estimate along with higher and lower estimates as part of a probability distribution. A more complete explanation of the Ascent model is included as Appendix 3 to this report.

Figure 16 demonstrates the difference between deterministic and stochastic models

*Figure 16: Stochastic Model Cost Distribution*

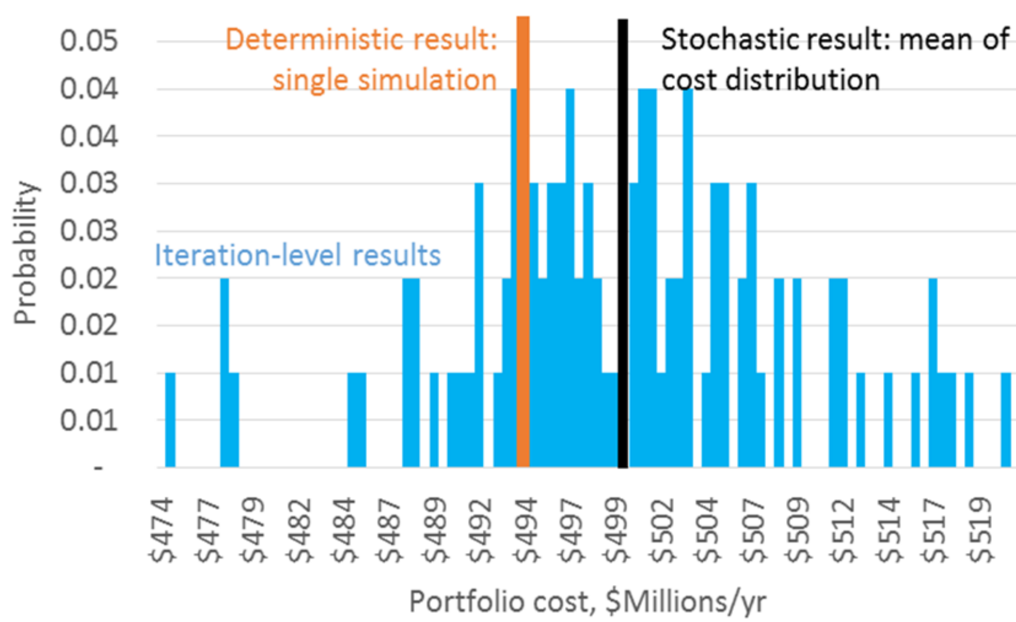


Figure 16 is a hypothetical and illustrates that predicting the future is uncertain. Any prediction over 20 years will likely miss the mark but knowing the probability of being off and by how much is very useful for planning. While a deterministic model yields a single cost estimate for a plan, the stochastic model runs 100 simulations of probable future conditions based on the underlying probability distributions of key inputs. Each run produces a plan's cost estimate. This provides additional information for planners. For example, a wide distribution of possible outcomes implies less certainty of future conditions and is riskier than a narrow distribution. In this way a measure of financial risk can be added to the modeling program.

The IRP uses both the mean result from the stochastic model to estimate each strategy's present value cost over the planning period and its cost distribution as a measure of financial risk over the planning horizon.

Generation reliability can be incorporated into the model by two methods. First, the model can be used to identify a generating portfolio that meets target generating reliability. For example, the industry standard target is the probability of one-day loss of load in ten years or alternatively, .1 in one year (also referred to as "Loss of Load Hours"). Second a constraint can be used to set a Midcontinent Independent System Operator (MISO) required capacity requirement with reserve margin. Since the BWL must adhere to MISO reliability requirements, this later method was used in this IRP.

BWL customers have also strongly recommended environmental stewardship as a planning goal. To incorporate the environmental impact of planning options, the Ascent model provides information used to calculate emissions data for the various generating portfolios utilized during the planning process. It also incorporates a stochastic process for weather and climate related effects to provide more detailed and accurate data on renewable energy generation.

The modeling process begins by creating strategies for meeting the future energy needs of the BWL's customers. For example, one strategy might be taking additional steps to reduce the BWL's carbon footprint by relying more on renewable energy than the reference case. Each strategy will yield a different 20-year present value cost. Each will also be characterized by a different level of financial risk. Most will differ in their effect on system operating flexibility. The portfolios' operating performances will also provide information on air emissions. With this data and the use of metrics, planners can evaluate the economic, operational, and environmental tradeoffs among the different strategies.

## Model Assumptions

Table 10 records the assumptions used in the modeling program for the IRP. The assumptions shown were used for modeling the resource selections, financial results, and performance of each strategy.

*Table 10: IRP Assumptions*

| Assumption | Value | Source |
|---|---|---|
| Modeling Software | ARS/PowerSimm | Ascent |
| Study Period | 2021-2040 | BWL Staff |
| Model Region | Lansing, MI | BWL Staff |
| Weighted Cost of Capital | 4.66% | BWL Staff |
| Retail Sales Growth | 1.6% | BWL Staff |
| Energy Waste Reduction | .8% | GDS Study |
| Demand-side Management | | GDS Study |
| Generating Plant Retirements | Eckert 12/31/2020<br>Erickson 12/31/2025<br>Belle River 12/31/2029 | BWL Staff |
| Natural Gas Cost ($/MMBtu) | 2020 $2.14<br>2030 $2.83 | S&P Global |
| Coal Cost ($/MMBtu) | 2020 $0.70<br>2030 $0.85 | S&P Global |
| Renewable Energy Capacity Factor | Solar tracking 22%<br>Solar Fixed panel 15%<br>Wind 36% | BWL Staff, Actual Project Performance, and Proposed Projects |
| Renewable Energy Capacity Credit | Solar 50%<br>Wind 15% | Midcontinent Independent System Operator |
| Market Energy Price Forecast Lansing Price Node ($/MWh) | 2020 $27.85<br>2030 $28.82 | S&P Global |
| Capacity Credit Price ($/kW/Mo) | 2020 $0.92<br>2030 $1.23 | |
| Transmission Cost | | BWL Staff |
| Inflation rate | | CBO January Report *The Budget and Economic Outlook: 2019-2029* |

## Strategies for Meeting Future Energy Requirements

The IRP developed 4 principal strategies and 9 resource sensitivities strategy permutations to meet future electric generation needs. The strategies are used to develop a long-term goal of eliminating coal from the BWL's generating assets, rely more on clean energy, and reducing emissions while maintaining reliability and affordability.

The first strategy is our reference case which begins with the current plan of reaching 30% clean energy in 2020, and includes the retirement of the Eckert plant December 31, 2020, Erickson in 2025, and Belle River in 2029/2030. In the reference case, the BWL's energy waste reduction continues with a goal of approximately 1% retail electric savings annually. The remaining 3 strategies have been developed based on stakeholder input and trends occurring in the industry and address several planning questions.

Table 11, reproduced below, displays the strategies, resource sensitivities and purpose of each.

*Table 11: IRP Strategies and Sensitivities*

| Strategy | Description | Purpose |
|---|---|---|
| **1.0 Reference** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, 1% annual energy waste reduction, all other options optimized | Reference incorporates current resource plan |
| **1.1** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2021, 1% annual energy waste reduction, all other options optimized | What is the impact of Erickson early retirement on the reference case? |
| **1.2** | Current plan 30% clean energy by 2020, 40% in 2030, Erickson retirement 2021, maximum cost-effective energy waste reduction (all 5 bins), all other options optimized | What is the effect of maximum energy waste reduction (all 5 bins) on the reference case with Erickson early retirement? |
| **1.3** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, minimum energy waste reduction (bin 1 only), all other options optimized | What is the effect of reducing energy waste reduction (bin 1 only) on reference case? |
| **1.4** | Current plan 30% clean energy by 2020, 40% in 2030, Erickson retirement 2025, maximum energy waste reduction (all 5 bins), all other options optimized | What is the impact of maximum energy waste reduction (all 5 bins) on the reference case? |
| **1.5** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, 1% annual energy waste reduction, high peak demand growth, all other options optimized | What is the impact of higher customer peak demand growth on the reference case? |
| **1.6** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, 1% annual energy waste reduction, high incentives for electric vehicles, all other options optimized | What is the impact of incentivizing electric vehicle adoption on the reference case? |
| **1.7** | Current plan 30% clean energy in 2020, 40% in 2030, Erickson retirement 2025, 1% annual energy waste reduction, high incentives for customer onsite distributed generation options, all other options optimized | What it the impact of incentivizing distributed generation on the reference case? |
| **1.8** | Current plan 30% clean energy by 2020, 40% in 2030, Erickson retirement 2025, maximum energy waste reduction (all 5 bins), high incentives for electric vehicles and customer onsite distributed generation, all other options optimized | What is the impact of maximum energy waste reduction (all 5 bins) on the reference case? |
| **2.0** | State standard of 15% renewable energy through 2021 and minimum energy waste reduction (bin 1 only) | How does the reference case compare to the State requirements? |
| **3.0** | 30% clean energy by 2020, 50% in 2030, Erickson retirement 2025, 1% energy waste reduction, all other options optimized | What is the impact of increasing the clean energy goal to 50% on the reference case? |
| **3.1** | 30% clean energy in 2020, 50% in 2030, Erickson retirement 2025, maximum energy waste reduction (all 5 bins), all other options optimized | What I the impact of increasing the clean energy goal to 50% on the reference case including maximum energy waste reduction (all 5 bins)? |
| **4.0** | 30% clean energy in 2020, 50% renewable energy in 2030, Erickson retirement 2025, 1% energy waste reduction, all other options optimized | What is the impact of increasing the renewable energy goal to 50% on the reference case? |

## Modeling Results

Table 12 shows the modeling results from each strategy including the amounts, types, and schedules of resource selections. A quick review indicates that no new thermal generation is selected over this planning period. Instead, varying amounts of energy waste reduction, renewable energy, batteries, demand response, and distributed generation comprise the selected resource portfolios.

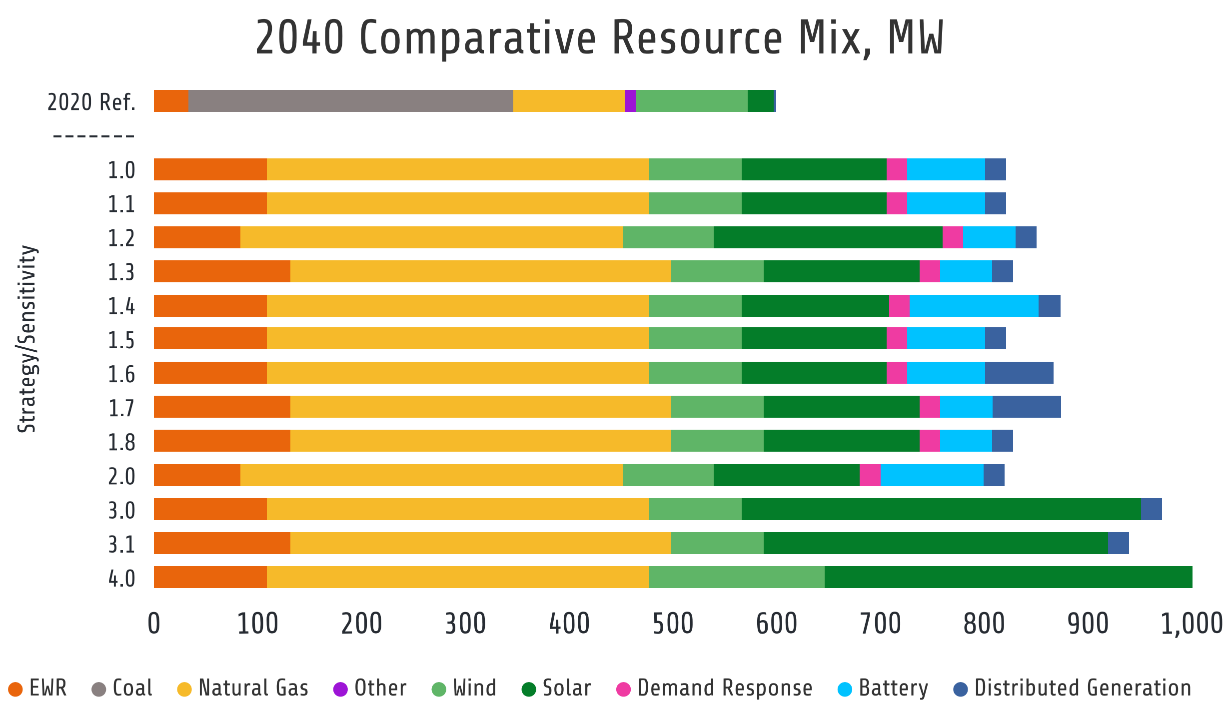
*Table 12: IRP Strategy Resource Selections*

| Strategy | 2021 | 2022 | 2023 | 2025 | 2030 | 2032-36 |
|---|---|---|---|---|---|---|
| 1.0 | 10 MW Solar, 1% Annual EWR | 80 MW solar | 26 MW Solar | Erickson Retirement | 12 MW Demand response, 75 MW 4-hour battery | |
| 1.1 | 10 MW Solar, 1% Annual EWR, Erickson retirement | 80 MW solar | 26 MW Solar | | 12 MW Demand response, 75 MW 4-hour battery | |
| 1.2 | 10 MW Solar, all 5 EWR bins, Erickson retirement | 80 MW Solar | 26 MW Solar | | 12 MW Demand Response, 50 MW 4-Hour Battery, 10 MW Solar | |
| 1.3 | 10 MW Solar, C&I bin 1 EWR only | 80 MW Solar | 26 MW Solar | Erickson Retirement | 12 MW Demand Response, 50 MW 4-hour battery, 75 MW Solar | 5 MW Solar |
| 1.4 | 10 MW Solar, all 5 EWR bins | 80 MW Solar | 26 MW Solar | Erickson Retirement | 12 MW Demand Response, 50 MW 4-hour battery, 10 MW Solar | |
| 1.5 | 10 MW Solar, 1% Annual EWR | 80 MW Solar | 26 MW Solar | Erickson Retirement | 12 MW Demand Response, 125 MW 4-hour Battery, 1.5 MW Solar | |
| 1.6 | 10 MW Solar, 1% Annual EWR, high electric vehicle incentives | 80 MW Solar | 26 MW Solar | Erickson Retirement | 12 MW Demand Response, 75 MW 4-hour Battery | |
| 1.7 | 10 MW Solar, 1% Annual EWR, high electric distributed solar incentives | 80 MW Solar | 26 MW Solar | Erickson Retirement | 12 MW Demand Response, 75 MW 4-hour Battery | |
| 1.8 | 10 MW Solar, all 5 EWR bins, high electric vehicle and distributed solar incentives | 80 MW Solar | 26 MW Solar | Erickson Retirement | 12 MW Demand Response, 50 MW 4-Hour Battery, 10 MW Solar | |
| 2.0 | 10 MW Solar, C&I bin 1 EWR only | 80 MW Solar | 26 MW Solar | Erickson Retirement | 12 MW Demand Response, 100 MW 4-Hour Battery | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 3.0 | 10 MW Solar, 1% Annual EWR | 80 MW Solar | 26 MW Solar | Erickson Retirement | 195 MW Solar | 50 MW Solar |
| 3.1 | 10 MW Solar, all 5 EWR bins | 80 MW Solar | 26 MW Solar | Erickson Retirement | 170 MW Solar | 20 MW Solar |
| 4.0 | 10 MW Solar, 1% Annual EWR | 80 MW Solar | 26 MW Solar | Erickson Retirement | 210 MW Solar, 40 MW Wind | 10 MW Solar, 40 MW Wind |

The IRP is used to determine the need for incremental generating resources to augment and complement or replace existing generating assets. This will change the mix of generating assets over time as units retire, purchase power agreements expire and additional resources are added to the portfolio. A look at the comparative resource mix between the years 2020 and 2040, based on installed capacity, for each strategy is shown in Figure 17.

Figure 17: Comparative Strategy Resource Mix




## Strategy Analysis

To help select among the multiple scenarios, the BWL developed several metrics. The metrics are based on the goals described previously and are used to help compare the performance of the various scenarios. They consist of 3 categories and 8 individual measures. The financial category identifies each strategy's total cost on a present value basis and the tradeoff between the plan total cost and the rates that it produces. The least present value cost plan may not yield the lowest rate.

The financial category also contains a financial risk measure for each strategy. Just as the cost of each plan differs so does the financial risk to which it exposes the BWL. Bear in mind that the least cost plan may not be the least risk plan. Likewise, a higher cost plan may be less risky. An important attribute of an IRP is to account for the risk exposure of a plan as well as its cost.

Operational flexibility has been adopted to help compare the flexibility each strategy makes to the BWL's electric operations. This includes how much of the BWL's generating assets are dispatchable and can be used to follow its customers' varying demands for electricity. Flexibility is important for both reliability and economic operations of the BWL's generating system. It also includes a measure of the diversity among each strategy's generating technologies. Diversity among generation technologies can help mitigate future financial and operating risks associated with over reliance on any one generating technology.

The environmental category was adopted to be responsive to the BWL's mission as environmental stewards and stakeholder recommendations. This category measures each strategy's carbon emission reductions as well as the reductions of NAAQS components SO2 and NOx, which are precursors to PM2.5, another criteria emission. Table 13 describes each category metric and the calculation for the metric.

*Table 13: IRP Metrics*

| Category | Measure | Description | Formula |
|---|---|---|---|
| **Financial and Risk** | Net Present Value Revenue Requirements (NPV) | Portfolios' present value revenue requirements 2021-2031 | $\sum RR/((1+k)^n))$ |
| | Rate Impact | Rate impacts measured by present value NPV and present value of sales (2021-2031 | $NPV/\sum Sales/((1+K)^n)$ |
| | Financial Risk Premium – Accumulated NPV | Measure of financial risk based on the cost of scenarios that are above the median cost portfolio | ∑Cost of Scenarios Greater than Median |
| **Operating Flexibility** | Percentage of Dispatchable Generation | Amount of generation that can be dispatched to meet load changes | ∑MW Dispatchable Generation/∑total MW Generating Capacity |
| | Resource Diversity Index | Measure of the diversity of generation technology adopted by the plan | $\sum n(n-1)/(N(N-1))$ |
| **Environmental** | Emissions Reduction from 2005 - $CO_2$ | Percentage $CO_2$ emissions reduction from 2005 | $\sum CO_2$ Emissions/$\sum$2005 $CO_2$ emissions |
| | Emissions Reduction from 2005 – $NO_X$ | Percentage $NO_X$ emissions reduction from 2005 | $\sum NO_X$ emissions/$\sum$2005 $NO_X$ emissions |
| | Emissions Reduction from 2005 - $SO_2$ | Percentage $SO_X$ emissions reduction from 2005 | $\sum SO_X$ Emissions/$\sum$2005 $SO_X$ Emissions |

The planning period is 20 years. Many industry changes are expected over that time and will almost certainly cause changes in future plans. The purpose of the IRP is to identify near-term action to meet future electric energy needs. This can be accomplished by segmenting the planning period into the first 10 years as well as the full 20-year planning period. We show selected metrics for the 10-year period as well as the entire 20-year planning horizon.

## Metric Results

Each strategy was also evaluated against the metrics discussed previously for both the first 10 years and then the entire 20-year period. The results appear in Table 14 for the 10-year period and Table 15 for the entire 20-year period.

*Table 14: Ten Year Metric Results*

| Strategy | Net Present Value Revenue Requirement (NPV) | Financial Risk Premium - Accumulated NPV | Rate Impact | Dispatchable Generation % | Resource Diversity Index | Emissions Reduction from 2005 - CO2 | Emissions Reduction from 2005 - NOx | Emissions Reduction from 2005 - SO2 |
|---|---|---|---|---|---|---|---|---|
| 1.0 | $917,222,985 | $223,151,056 | $47.67 | 57.0% | 0.516 | -79.0% | -96.0% | -99.9% |
| 1.1 | $901,328,212 | $173,449,713 | $46.85 | 57.0% | 0.516 | -79.0% | -96.0% | -99.9% |
| 1.2 | $901,960,051 | $174,454,956 | $47.35 | 54.0% | 0.513 | -79.0% | -96.0% | -99.9% |
| 1.3 | $911,685,471 | $221,695,285 | $46.35 | 52.0% | 0.522 | -79.0% | -96.0% | -99.9% |
| 1.4 | $918,002,289 | $222,822,720 | $48.19 | 54.0% | 0.513 | -79.0% | -96.0% | -99.9% |
| 1.5 | $977,074,473 | $219,194,478 | $46.69 | 60.0% | 0.559 | -78.0% | -96.0% | -99.9% |
| 1.6 | $918,746,598 | $222,726,457 | $47.72 | 57.0% | 0.516 | -79.0% | -96.0% | -99.9% |
| 1.7 | $918,138,027 | $222,793,960 | $47.72 | 57.0% | 0.518 | -79.0% | -96.0% | -99.9% |
| 1.8 | $927,203,941 | $223,238,318 | $48.64 | 54.0% | 0.516 | -79.0% | -96.0% | -99.9% |
| 2.0 | $912,751,743 | $221,855,076 | $46.41 | 60.0% | 0.522 | -79.0% | -96.0% | -99.9% |
| 3.0 | $917,326,777 | $222,004,933 | $47.68 | 41.0% | 0.518 | -80.0% | -97.0% | -99.9% |
| 3.1 | $925,607,320 | $221,804,428 | $48.59 | 41.0% | 0.526 | -80.0% | -97.0% | -99.9% |
| 4.0 | $919,299,188 | $221,934,046 | $47.78 | 39.0% | 0.561 | -80.0% | -97.0% | -99.9% |

*Table 15: Twenty Year Metric Results*

| Strategy | Net Present Value Revenue Requirements (NPV) | Financial Risk Premium - Accumulated NPV | Rates - Accumulated NPV | Dispatchable Generation % | Resource Diversity Index | Emissions Reduction from 2005 - CO2 | Emissions Reduction from 2005 - NOx | Emissions Reduction from 2005 - SO2 |
|---|---|---|---|---|---|---|---|---|
| 1.0 | $1,468,954,993 | $295,795,481 | $49.55 | 56% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.1 | $1,453,537,192 | $243,462,058 | $49.03 | 56% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.2 | $1,441,761,339 | $244,807,319 | $49.35 | 53% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.3 | $1,468,269,777 | $293,520,966 | $47.70 | 51% | 0.529 | -81.0% | -97.0% | -99.9% |
| 1.4 | $1,457,294,707 | $296,086,993 | $49.89 | 53% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.5 | $1,603,042,069 | $290,305,299 | $48.99 | 59% | 0.567 | -79.0% | -96.0% | -99.9% |
| 1.6 | $1,471,035,127 | $295,328,658 | $49.58 | 56% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.7 | $1,483,467,392 | $295,337,724 | $50.04 | 53% | 0.577 | -81.0% | -97.0% | -99.9% |
| 1.8 | $1,486,727,059 | $296,082,536 | $50.84 | 50% | 0.577 | -82.0% | -97.0% | -99.9% |
| 2.0 | $1,484,707,938 | $293,816,682 | $48.24 | 60% | 0.526 | -80.0% | -97.0% | -99.9% |
| 3.0 | $1,466,070,688 | $289,347,912 | $49.46 | 38% | 0.537 | -83.0% | -97.0% | -99.9% |
| 3.1 | $1,472,896,664 | $289,008,833 | $50.42 | 40% | 0.542 | -83.0% | -97.0% | -99.9% |
| 4.0 | $1,485,622,011 | $288,973,464 | $50.12 | 36% | 0.603 | -83.0% | -97.0% | -99.9% |

Evaluating these results shows tradeoffs for both the categories of metrics and the time-period under study. For example, a strategy that may perform well with rates may increase the financial risk to the BWL. Likewise, the strategy that may be financially best over the 10-year period will not necessarily be the best over 20 years. One way to evaluate these tradeoffs is to use a "Heat Map" to visually compare the metric results. Figure 18 represents the 20-year metric results for each strategy and resource sensitivity. Results shaded in green are among the one-third best results for that metric measure while those shaded in red are among the lowest scoring one-third for the metric measure.

*Figure 18: Comparative Metric*

| Strategy | Net Present Value Revenue Requirements (NPV) | Financial Risk Premium - Accumulated NPV | Rates - Accumulated NPV | Dispatchable Generation % | Resource Diversity Index | Emissions Reduction from 2005 - CO2 | Emissions Reduction from 2005 - NOx | Emissions Reduction from 2005 - SO2 |
|---|---|---|---|---|---|---|---|---|
| 1.0 | $1,468,954,993 | $295,795,481 | $49.55 | 56% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.1 | $1,453,537,192 | $243,462,058 | $49.03 | 56% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.2 | $1,441,761,339 | $244,807,319 | $49.35 | 53% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.3 | $1,468,269,777 | $293,520,966 | $47.70 | 51% | 0.529 | -81.0% | -97.0% | -99.9% |
| 1.4 | $1,457,294,707 | $296,086,993 | $49.89 | 53% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.5 | $1,603,042,069 | $290,305,299 | $48.99 | 59% | 0.567 | -79.0% | -96.0% | -99.9% |
| 1.6 | $1,471,035,127 | $295,328,658 | $49.58 | 56% | 0.526 | -81.0% | -97.0% | -99.9% |
| 1.7 | $1,483,467,392 | $295,337,724 | $50.04 | 53% | 0.577 | -81.0% | -97.0% | -99.9% |
| 1.8 | $1,486,727,059 | $296,082,536 | $50.84 | 50% | 0.577 | -82.0% | -97.0% | -99.9% |
| 2.0 | $1,484,707,938 | $293,816,682 | $48.24 | 60% | 0.526 | -80.0% | -97.0% | -99.9% |
| 3.0 | $1,466,070,688 | $289,347,912 | $49.46 | 38% | 0.537 | -83.0% | -97.0% | -99.9% |
| 3.1 | $1,472,896,664 | $289,008,833 | $50.42 | 40% | 0.542 | -83.0% | -97.0% | -99.9% |
| 4.0 | $1,485,622,011 | $288,973,464 | $50.12 | 36% | 0.603 | -83.0% | -97.0% | -99.9% |

## Observations

A number of observations can be made from a review of the metrics and the generation capacity selected by the model. Among these are the following.

- While present value revenue requirements, rates, operational performance, and emissions differ among the strategies, there is only one strategy that may be labeled an outlier, the high peak growth strategy. This strategy has a net present value cost 8% higher than the low-cost strategy in the 10-year analysis and 11% higher in the 20-year analysis.

- Over the 10 and 20-year periods, the difference between the lowest and highest net present value cost scenarios excluding the high-growth strategy is 3%.
- The variation in the financial risk measure is greater than the variation in net present value cost and in rates. The difference between the lowest and highest risk strategy in the 10 and 20-year analyses is 22% and 29% respectively.
- Installed generating capacity grows over time in many scenarios because required capacity credits and capacity factors of renewable generation options are less than the thermal generation that it replaces
- Most scenarios favor growth of solar generation
- All scenarios meet the required reserve margin reliability standard
- Retiring Erickson early produces the least cost plan across the strategies.
- The difference between continuing the 1% energy waste reduction program or increasing it to the maximum is not significant. While 1% yields a lower rate, the maximum energy waste reduction produces the lowest long-run net present value cost.
- The growth of Distributed Generation and electric vehicles is forecast to be slow to moderate but consistent and do not make a major impact on cost and operations unless high incentives are paid for customer adoption of these options. High incentives produce slightly higher net present value cost and rates, and slightly less financial risk compared to the reference case.
- Adopting a 50% clean energy goal for 2030 does not produce a materially different cost and risk profile over the 10-year analysis and is less costly and risky over the 20-year period.
- Additions to renewable energy are beginning to offset additional energy waste reduction and vice versa
- Batteries add to operating flexibility by increasing dispatchable energy and contributing to technology diversity to meet peak demand
- Operational metrics indicate that dispatchability is highest in the reference case and lower in the renewable and accelerated clean energy cases
- The opposite holds for resource diversity, with the clean energy and renewable sensitivities showing more diversity than the reference case.
- Major emissions reductions occur in all scenarios and sensitivities, with slight more occurring in the clean energy sensitivities. Most emission reductions occur in the first 10 years.

## Recommendations

For near-term decisions over the next 5 to 10 years, the goal of 50% clean energy in 2030 (strategy 3.0) scores well with the metrics as seen on Figure 18. Though slightly more expensive than the reference case in the first 10 years, it is less expensive and less financially risky over the 20-year period. It also represents a balance by providing more generating diversity and less emissions. In addition to wind and solar projects now being developed for the BWL, the goal of 50% clean energy in 2030 will not require additional projects until 2025, and relies on continuation of the Hometown Energy Savers energy waste reduction program.

The recommendation includes a measured, consistent growth in the Hometown Energy Savers energy waste reduction program. The maximum energy waste reduction contributes to lower present value revenue requirements over the long-term. An additional advantage of the energy waste reduction program is that as it displaces both thermal and renewable energy investment. These investments are long-term fixed cost commitments. Over a longer time, managing these commitments offers some financial and operating flexibility to the BWL. This advantage should be a consideration in planning future energy waste reduction programs as part of a plan to reach 50% clean energy in 2030.

As the metrics demonstrate, major emission reductions in all 3 measured emissions occur in the first 10 years of the plan. This provides an opportunity to explore a goal of reaching carbon neutrality in 2040.

Carbon neutrality includes both reducing carbon emissions and mitigating, or offsetting, carbon emissions. By adopting this goal, the BWL would join major U.S. utilities, non-utility companies, States, Cities, and Countries that adopted a carbon neutral goal. This goal would face challenges and depend on technology improvements to continue balancing all the BWL's planning goals. However, over the next 20 years, it is reasonable to project that continued technological improvements in energy production and storage will occur. While a defined plan for carbon neutrality is yet to be explored, a process that identifies and incorporates these improvements into an ongoing carbon neutral plan is the BWL's future.

As noted previously, the process of undertaking this IRP has led to identification of trends and the need for additional studies in preparation for future planning endeavors. This IRP includes recommendations for these studies.

- A comprehensive study of the BWL's distribution system in preparation for more extensive distributed generation and electrification.
- Monitor and assess customer energy related technology options that may impact customers' ability to manage energy use.
- Further develop metrics to provide for more transparency and to help guide its resource recommendation and involve customers in the process.
- A detailed study be undertaken to determine methods, options, schedule and costs for reaching carbon neutrality in preparation for the next IRP.

# Appendix A: Public Engagement

Since March 2019, the Lansing Board of Water and Light has reached out to the Greater Lansing area to discuss program development, acquire feedback, and encourage suggestions from diverse organizations such as local governments, municipal representatives, neighborhood associations, and industrial and commercial businesses. Table 16 below highlights some the mentioned organizations.

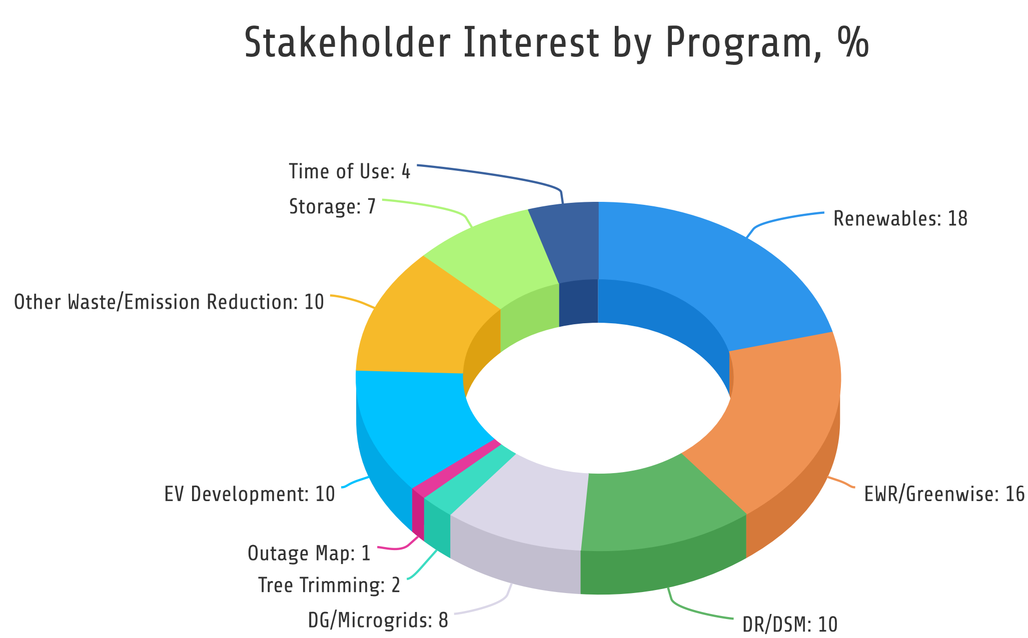
*Table 16: Stakeholder Group IRP Meeting List*

| Category | Participant |
|---|---|
| Local Governments | City of East Lansing |
| | Delta Township |
| Local Leaders | David Price |
| | Ken Ross |
| | Douglas Jester |
| | Sandra Zerkle |
| | Tracy Thomas |
| | Beth Graham |
| | Joan Nelson |
| | Derrell Slaughter |
| | Andy Schor |
| Neighborhood and Other Associations | Neighborhood Stakeholders |
| | League of Women Voters |
| | Lansing Chamber of Commerce |
| | Michigan Manufacturer's Association |
| | LEAP Economic Development |
| | Allen Street Neighborhood Association |
| | LEET |
| Commercial and Industrial Stakeholders | Emergent BioSolutions |
| | Cintas |
| | General Motors |
| | City of Lansing |
| | State of Michigan |

| | |
|---|---|
| | Sparrow Hospital |
| | Meijer, Inc. |
| | Jackson National Life |
| | Liquid Web. Inc. |
| | Lansing Community College |
| | Auto Owner's Insurance |
| | McLaren-Greater Lansing |

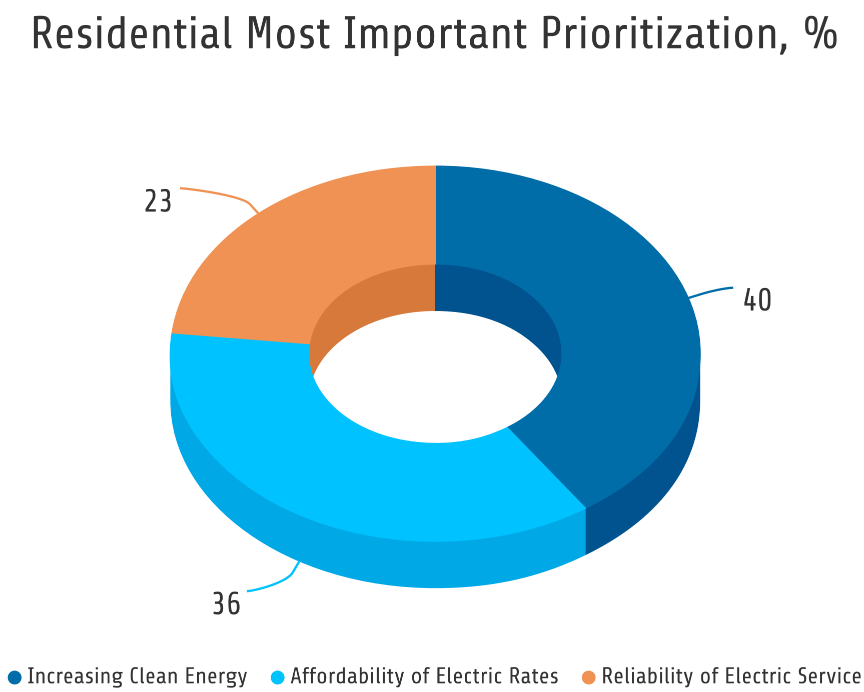
These stakeholder meetings provided valuable recommendations to modify programs and to continue to develop innovative programs that can meet Greater Lansing's needs. Discussion topics included: sustainability and environmental responsibility, industry trend familiarity, rate flexibility and energy management, economic development and other goals, and a strategic planning discussion for opportunities and feedback. Stakeholders were encouraged to share their thoughts on sustainability goals, onsite renewable development or joint community projects, and how BWL can assist in these sustainability goals through contracts and rate-based products. Additionally, talking points were provided that included: distributed generation, demand response, electric vehicles, battery storage, net-zero buildings, energy waste reduction, microgrids, renewable energy credits, and more. The specific programs that exhibited the most interest based on frequency are listed below in Figure A-1

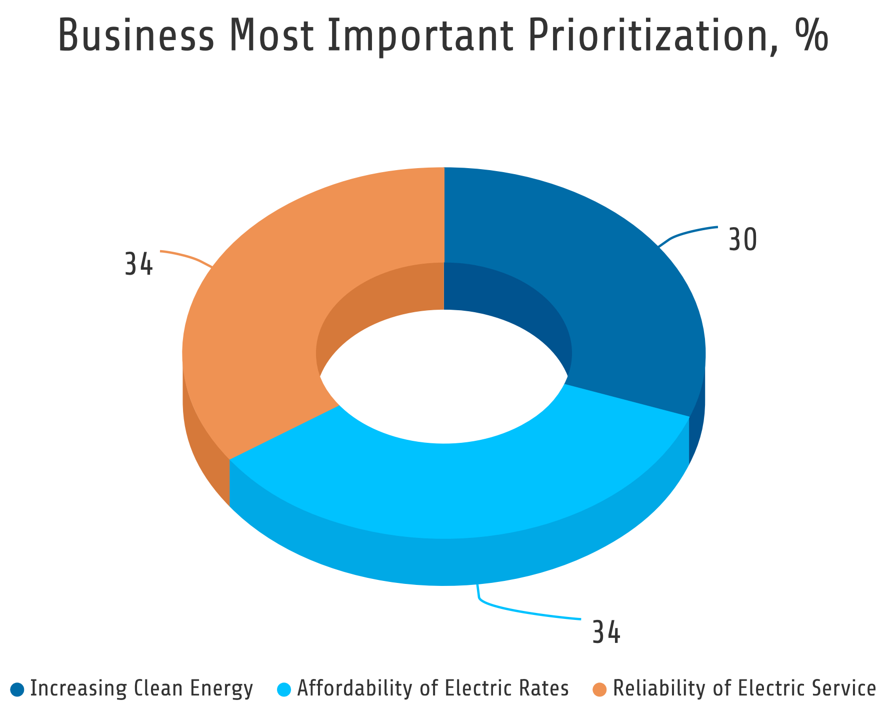
*Figure A-1: Stakeholder Interest in Current and Future BWL Programs Ranked by Frequency*




In a 3rd party study, stakeholders were asked to provide a recommendation for BWL's priorities as the organization plans for the coming decades and aims to balance reliability, economic and environmental goals while mitigating risks and meeting regulations. This information for both residential and business stakeholders is displayed in Figure A-2 below.

*Figure A-2: Stakeholder Feedback on BWL Prioritization*




The information gained provides a foundation for long-term planning efforts, helps inform the decisions that will be made by the Commission for the Strategic Plan, and serves as a way-finder in the determination to meet future electric needs.

Additionally, the Lansing Board of Water & Light hosted a series of open houses to gather residential feedback. Members of the public were invited to attend the open houses to ask questions and offer suggestions to help shape the IRP. The meeting dates and locations are listed in Table 16 below.

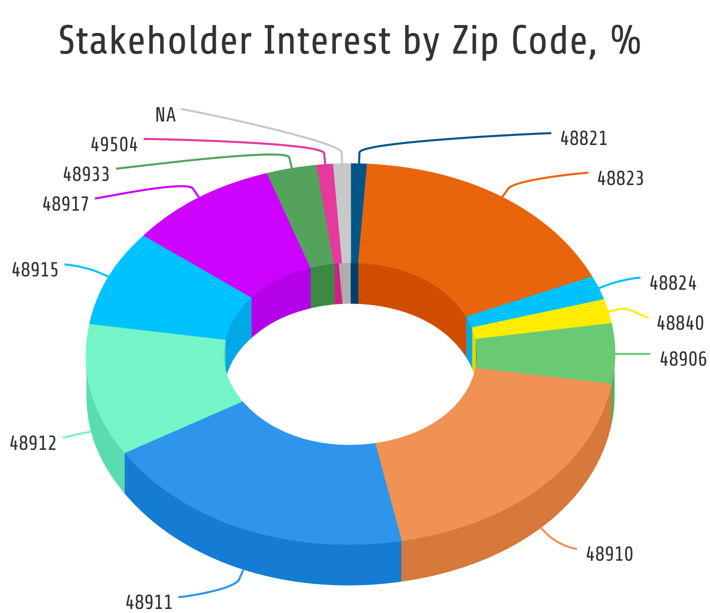
*Table 16: IRP Open House Meeting Logistical Information*

**Integrated Public Open House Meetings**

| Date | Location |
|---|---|
| 11/06/2019 | BWL REO Depot |
| 11/07/2019 | East Lansing Public Library |
| 11/13/2019 | Delta Township District Library |
| 11/14/2019 | Alfreda Schmidt Center |
| 11/19/2019 | BWL REO Depot |

Stakeholders could offer suggestions on paper or digital formats using resources provided through social media and at each meeting. The questionnaire requested personal information like stakeholder area codes, open-ended opinions on any topic, and a recommendation for BWL's top priorities. The stakeholder area breakdown is displayed in Figure A-3: and the feedback is listed in Table 17.

*Figure A-3: Stakeholder Location Breakdown by Zip Code*



| Recommended Prioritization | Stakeholder Feedback |
|---|---|
| **Environmental** | Lansing has an opportunity to be a leader into the next century. Let's ramp up our investment in clean renewables. Despite the difficulties mid-Michigan's economy has had, we can at least prioritize a clean future for the next generations. We don't need to be stuck in the past! Please listen to new leadership with vision! |
| **Environmental** | Please don't drag your feet on moving as quickly as possible toward maximizing solar power. Other "clean" fuels are not enough. |
| **Resiliency** | We are coming to a time of awareness and knowledge where we have an opportunity to transform into sustainable, low cost, reliable and environmentally restorative municipal resource. I want to start by thanking BWL employees and board for providing electricity and water stewardship. I write on a laptop fully charged because of the resources BWL provides. Thank you. With that said, we need to catch up - fast! Lansing, MI is located on 5 watersheds that feed all the Lakes of Michigan. We are not only the focal point for Michigan's Capitol city and leadership, we are the hub for clean water that will eventually end up in Lake Michigan and onward onto the Mississippi River. Science has taught us that if we do not change how we acquire resources and utilize them, we are destined to expire like Greek cultures who died from the lead poisoning in their aqueducts feeding the city. I decided to add my suggestions under resiliency, because I believe that all the issues we need to address can fall under this category. We need to adapt our city power and water supply into a sustainable environmentally reparative resource. Science has informed us that Fracking leads to toxic water supplies, earthquakes, and depletion of unique niches of fauna that cleans our air and provides Oxygen. How many years ago did BWL have the chemical accident over at Morris Park area, leaking how many gallons of oil into the river? We have already seen damage to our environment on our reliance to oil and natural gas. Solar energy and wind energy have been proven to reduce use of Oil and Fracking resources. Both have a lower threshold for creating environmental toxins.<br><br>I think it is important for BWL to begin looking at returning to a role of stewardship when it comes to the water supply in the Lansing area. I personally live next to a water drain that has become a natural wetland. These pockets of nature are exactly what we need more of. Lansing stands in the forefront of water stewardship and maintaining a clean water supply. With that said, the electrical end of our city resource BWL has a tendency to add to the pollution. Fracking is not clean. How might we use our water supply to increase electricity while reducing the reliance of natural gas? How might we use hamlets of wetlands, marshes, and prairies to promote spaces for Air power and solar power? I think these are possible questions for BWL to answer. The science is out there. The technology is across the sea and countries have mastered the chance to reduce waste while creating sustainable energy. Norway, Germany, and even India have models on how we might move forward.<br><br>I am asking BWL to focus on relearning the role of stewards of resources, rather than corporate negotiators. The environment is most important to the resilience of BWL. We need to focus on Solar and Air energy as a tool to generate electricity. We need to continue to focus on clean water and clean soil. I do believe this all needs to be low cost or at least shared cost. Asking the property owners to take all the cost will only add to coming recessions. It is important for BWL to work with contractors who will not gouge the prices or burden the populous of non-existent income. This is not a money-making project for the political or merchant stakeholders involved either.<br><br>In the coming years, we need to catch up on sustainable stewardship for electricity, sewage, and water. We need to turn away from oil-based energy, because it is no longer sustainable and is doing damage to our soils. All of these suggestions augment resilience as a municipal resource. |
| **Environmental** | Scientists agree that we have limited time to address climate change. What an important opportunity for BWL to be a leader in using sustainable resources. Please consider even more dynamic changes using renewable resources. This will ultimately be cost effective. |
| **Environmental** | At your IRP open houses, I was sad not to see a great emphasis on shifting to renewable energy sources. Renewables are the way of the future, indeed our only hope, because of our drastic climate emergency. Renewables are cheaper in the long term and getting cheaper in the short term as well. If you figure in the environmental costs of fracking for natural gas and the price volatility of fossil fuels |

| | |
|---|---|
| | in the future, it is unsound to invest in fossil fuel plants. Here are some suggestions: - Using open source bidding to bring in more creative options for generating power. - Focusing less on large power plants by building smaller modular units as needed, being open to using solar and wind. - Remove the limit on customer-installed solar panels, so that they can sell back to you as much as they can generate. As it is now, customers are limited to only being allowed to build as much as they are expected to use themselves. Why the limit? - Erect solar panels over Lansing's multiple parking lots and/or on local schools, warehouses, businesses, etc. MSU is touting their expected cost savings from their solar panels. - The IRP open houses did not allow for adequate public comment. I would like to see a hearing type of meeting with all the factors explained as to what modeling factors were used, especially the costs of the fuels for the proposed plants. I understand that the environmental costs of fossil fuels and the upstream (mining) pollution are not factored in to your planning process. It is dishonest to crow about "clean" natural gas. - Your goal of 40% cleaner by 2030 is too modest by far.Solar panels and windmills are money makers and our only hope of restraining climate change. Ignoring solar and wind comes at a terrible price. |
| **Environmental** | Please, please approach the move to renewables with more courage than the currently planned 2030 goal. |
| **Environmental** | Dear Lansing Board of Water and Light,<br><br>While we applaud the commitment to hold open houses and meet with stakeholders on the integrated resource plan (IRP), the LBWL should commit to hold a public hearing once the plan is proposed. The public should be able to comment on the IRP in the presence of the LBWL commissioners. This date and location should be set months in advance to create the opportunity for meaningful public engagement. This hearing should be recorded and available online in conjunction with an online comment period for people who are not able to participate in person. The LBWL's greenhouse gas models (GHG) use a flawed methodology to achieve an 80 percent reduction. When considering a scenario in the IRP with the construction of an additional methane-peaker unit, modelers have projected little to no emissions increases. However, climate impacts are not assessed in an accurate manner because the impacts of fuel source extraction and distribution are hidden. The LBWL should implement Scope I, II, & III carbon accounting standards for its emissions. The current assumptions obscure the true GHG emissions of LBWL's portfolio. Point-source emissions are not the full breadth or impact of the LBWL's energy resources. LBWL has not considered the true social and economic impact of GHG emissions in its cost assessment for the modeled scenarios. As a result, the true economic and social costs of the emissions obscure the true price to Lansing's residents. When these externalities are considered, cleaner options dramatically out-compete the proposed methane expansion and should be implemented.<br><br>In 2016, we suggested aggressive efficiency and renewables as a step towards replacing capacity from the retirements of Belle River, Eckert, and Erickson. Instead, a large methane plant was constructed. This plant is at risk of becoming a stranded asset when government policies and economics catch up to the realities of the climate crisis. That is, the cost of building an entirely new clean energy portfolio will become cheaper than the cost of continuing to run the methane plant. This means that LBWL's customers will likely be forced to pay for more expensive, dirty fossil fuels, and their stranded costs for decades to come. [https://rmi.org/insight/clean-energy-portfolios-pipelines-and-plants] New methane infrastructure will increase the risk portfolio of the LBWL and should be rejected.<br><br>LBWL's procurement process is flawed because it does not give renewable energy and energy storage a chance to compete. In 2018, LBWL issued a Request for Proposals (L-5404) for a "new, natural-gas-fired combined-cycle electric generating plant and 138 kV switchyard, with a nominal summer net capacity of 250 MW." Only vendors who could build a gas plant could hope to compete. In contrast, most utilities across the country utilize "all source request for proposals (RFPs)" as a best practice to ensure fair competition and to secure the least expensive options for ratepayers. For example, Northern Indiana Public Service Co. has issued several all source RFPs that are written so that different energy sources can compete on equal footing. In May 2018, NIPSCO issued an RFP that considered dispatchable and semi-dispatchable generation, renewable generation, and demand response, as well as emerging technologies such as storage. NIPSCO has estimated its resulting clean energy investments will save customers $4 billion over 20 years. We have asked LBWL repeatedly to issue an all-source RFP and let the market decide how to best meet the utility's capacity and energy needs, yet LBWL has refused to do so. The board should direct LBWL to issue an all-source RFP so Lansing customers are getting the best technologies the market has to offer. |

| | |
|---|---|
| | The LBWL should explore earlier retirement of its capacity in Belle River. At the open house, the modeling team shared that this scenario has been modeled. This information should be disclosed to the public and become a decision point in the final plan. Furthermore, here are some general comments on the climate situation. The Intergovernmental Panel on Climate Change recommends net zero portfolio GHG emissions in 2050. This will keep the planet within the safe 1.5 C range above pre-industrial levels.<br><br>The LBWL has not planned for a zero-carbon world. While an 80% reduction is laudable, it is not a scientifically-aligned goal. Traverse City (also a municipal utility) and Petoskey have both committed to 100% renewables. Ann Arbor has declared a climate emergency, stating its intention to transition to pursue similar goals. Cities of various sizes, income levels, and similar geographies have all made these pledges, suggesting there are no technical limitations to prevent the LBWL from a similar proposal. |
| **Low-Cost** | I would like to see BWL place affordability, so if there is a conflict between environmental and affordability, low cost is selected. |
| **Reliability** | |
| **Environmental** | Lower bills for Senior programs and people with low income. |
| **Environmental** | Great to hear that BWL installed 200+ MW solar on west side of Lansing in 2016. Need to do middle-scale solar on brown fields and large parking lots near central city. |
| **Reliability** | I would like to make some additional comments. Previously I wrote about batteries as a way to make the grid "renewable friendly". I would like to add that there is an additional benefit of grid integrated battery storage. Since batteries are DC and the grid is AC there needs to be electronics (ex. inverters) to make the transition between them. Inverters are also a great way to make reactive power. In addition to storing renewable energy for dispatch at a later time, a battery-inverter combination can be used to support the grid and improve power quality. Both power price and power quality are critical factors for economic development. By improving the quality of the LBWL grid and thereby attracting and retaining high quality jobs, the investment in batteries and the associated electronics can pay for themselves. |
| **Low-Cost** | |
| **Environmental** | |
| **Environmental** | Need to communicate and educate the cost and amount of being 100% renewable then reflect reliability and resiliency |
| **Reliability** | I appreciate the efforts made—trimming trees—to improve reliability. I came because I wanted to learn a little more about how BWL is increasing renewable energy sources knowing that even natural gas, being a fossil fuel and having environmental impacts to extract it, has its limitations. I want to do my part to help improve my efficiency in my home. |
| **Environmental** | I would like to see additional focus toward educating the public on ways to decrease energy consumption, especially concerning heating and cooling their homes. Showing people how much of a difference changing the thermostat by only a couple of degrees could make in their bills or explaining alternative ways to regulate their home's temperature (i.e. closing curtains) should be discussed more often. |
| **Environmental** | Human-driven climate change is accelerating.  It is the consensus of the world's climate scientists that humanity has only years to bend the curve of increasingly accelerating greenhouse gas emissions. But even that will not eliminate the prospect of catastrophic climate events — extreme droughts, larger and more intense fires, higher and more extensive flooding, extreme heat and cold waves, rising average world temperatures affecting the location and extent of agriculture leading to famine, the spread of disease vectors, increasing morbidity and mortality of children, and many other consequences inimical to not only human beings, but to the whole ecological system that is the Earth.It is greenhouse gases emitted by power plants, vehicles, warming permafrost, higher ocean temperatures, burning forests, and other sources causing this catastrophic rate of climate change. Reducing those emissions by striving to eliminate the use of fossil fuels, including natural gas, in favor |

| | |
|---|---|
| | of non-emitting renewable sources is essential to the survival of humanity and all other living things.Despite this urgent need to reduce/eliminate greenhouse gas emissions world-wide, LBWL has consistently stated that its priority, and what it believes to be the priority of its residential, commercial, and industrial communities, to be “affordable and reliable power,” whether or not fossil fuels are the source. “Pushing toward cleaner power” is only mentioned as a secondary goal.The materials that LBWL has provided to the public at its “open meetings” for developing its next IRP and in its website and any other materials that I’ve seen, NEVER acknowledges human-driven climate change nor the increasingly catastrophic weather driven events that it is causing. Nor does LBWL express the high degree need for urgency in “pushing toward cleaner power.” Nor has LBWL made a public effort to educate its customers as to the obstacles to eliminating fossil fuels or the relative cost and benefit of moving to exclusively renewable sources of energy more quickly that currently foreseen.LBWL posed the foundational “Questions” to consider (computer screen from PowerPoint presentation at the open house meetings). But nowhere does it provide the information necessary to even begin to arrive at the energy source options available and the degrees of financial and reliability levels associated with each option. Nor does LBWL identify the relative health and safety consequences to its customers that would be associated with each option.In the last IRP, LBWL presented 7 energy portfolios representing a variety of scenarios using various assumptions to the advisory committee consulted as part of the IRP process. Nothing of that nature has been provided to stakeholders in preparation for this upcoming IRP.Without recognizing climate change and the urgency of action, LBWL will not be eliminating the use of fossil fuels and reduction of greenhouse gas emissions as its priority while taking into consideration energy affordability and reliability. Innovation in the energy industry is also moving at an accelerating pace. LBWL seems to be ignoring that its assumptions in December 2019 will no longer be accurate in even December 2020. The cost of energy from renewable sources is continuing to drop and the capacity and cost of energy storage systems is also continuing to drop. LBWL has failed to identify the measures it will employ to continually update its assumptions and solutions to delivering electricity and water to its customers. LBWL doesn’t seem to think, or at least won’t explicitly admit, that its IRP has meaningful consequences to the pace of climate change. That’s just wrong and an abdication of its obligations to its customers |
| **Environmental** | Community involvement--and planning |
| **Reliability** | More wind energy power sources.<br>Promoting renewal sources with the state government.<br>Working with other states that are more likely to create solar power farms.<br>Is it possible to harness Great Lakes wave action to produce energy? Some states along the ocean coasts and countries in Europe are using that wave action as an energy source.<br>Decommission all nuclear power plants run by Consumers Energy, etc. |
| **Reliability** | This is pretty interesting to learn about the BWL's current plan, goals, strategies to promote the clean energy. Paul is the best! |
| **Environmental** | Please commit to as fast a transition as possible off coal & gas. BWL can do more to limit future energy demand by better communication with customers, especially large commercial customers by anticipating energy needs and encouraging efficiency measures and distributed power generation. The IRP must take account of the climate emergency both by drastically reducing emissions and managing the cost of maintaining the energy grid under increasingly severe weather.<br><br>Thank you for holding these public meetings to inform people about the IRP. Communication is important, and it has been difficult to find any specifics about BWL's plans through the website. I am also unclear on how new board members have been brought on without public input. |
| **Environmental** | It's critical that we stop burning fossil fuels and build the renewable energy production system of the future. Currently, BWL is retiring coal burning plants but replacing them with another fossil fuel. I would like to see a greater emphasis on energy efficiency and clean renewable energy. I would also like you to consider all of the negative externalities associated with the practice of fracking.Overall, I was impressed with this open house. |
| **Reliability** | While I'm not a BWL residential customer, my downtown Lansing office is. As a member of the greater Lansing community, I appreciate the efforts of the BWL to help residents understand their energy use and supply. |

| | |
| --- | --- |
| | As a public affairs professional with extensive energy background, I applaud BWL for its community relations work around the proposed IRP.  Hats off! Thank you. |
| **Low-Cost** | Well run informational session on the plan for BWL power generation and delivery future. |
| **Environmental** | I am here on behalf of the company I work for. We are a Swedish company with manufacturing facilities all over the world, including one in Lansing, Mich. The company is dedicated to sustainable business practices and the products we built aim to achieve energy efficiency for our customers too. That being said, we're being pushed by our executive team in Europe to promote the energy efficiencies we have now, and to have an eye on where we're going in the future too.<br><br>Long way around the barn to say: we have pressure from Europe to promote energy efficiency and sustainability as a competitive advantage. It's important to us and our customers. |
| **Reliability** | Thank you for the opportunity to learn about the BWL's 2020 IRP Plan. I appreciate your willingness to educate the public/customers about the long-term electric generation plan to meet the future energy needs of Lansing. These types of opportunities for stakeholders go a long way in creating good will and reassurance that the BWL has the community's best interest at the forefront of their decision making. Thank you again! |
| **Low-Cost** | |
| **Reliability** | I want to know why BWL doesn't have a peak power savings program like consumer energy.<br><br>Which allows for lower electricity rates when power is used during off peak hours.<br><br>This program would significantly lower prices for hundreds if not thousands of BWL customers like me. |
| **Low-Cost** | It is now clear that renewable energy is the cheapest source on the grid. The costs of solar PV and batteries are have fallen dramatically and will continue to do so. While there has been a lot of discussion about solar PV, the discussion around batteries has been lacking. Both solar PV and batteries are technologies and like any other technology they exhibit a "learning curve". This is a well understood phenomenon, where the cost of a technology declines as the volume of that technology increases. Now that battery electric vehicles are entering mass production, it is a certainty that the cost of batteries for integration with solar PV will drop in parallel. Please consider making investments in battery storage. Since there is great public interest in solar PV, I do not believe that an incentive program (above the federal) is needed. By investing in battery storage and making the grid more resilient to intermittencies, the LBWL can do much to make the grid "renewable friendly" and to keep our electricity costs competitive. |
| **Environmental** | I think the current target of 40% from renewables is far too low. I would hope it could be closer to 100%. Our climate needs relief NOW! I know such a plan would be more expensive, but we would be willing to pay more, within reasonable limits. |
| **Environmental** | I would like BWL to have no coal or gas fuel for their power. Lazard reports show that renewables have low and declining costs some of which are cheaper than coal/gas. |
| **Low-Cost** | Definitely energy efficient.  I would love to see different alternatives to using energy. My bills are really high, and I try to do what I can to save . We need to focus on this more so that everyone can actually get some relief. |
| **Low-Cost** | The surging Global #ElectricFueledVehicle, #EnergyStorage, #RenewableEnergy, #Sustainability, #IoT, #IIoT & #BlockChain...<br><br>The Epic #CleanEnergy Convergence will remake local, national & Global Value & Supply chains over the near term and the coming decade!<br><br>The bottom line from #WindPowerPlant's To #SolarPowerPlant's is the #FuelFreeFuelForever! |
| **Environmental** | This was a really cool experience, I am an environmental studies and sustainability major at GVSU and this peaked my interest. I toured the BWL Erickson plant this morning in one of my classes, and it |

| | |
|---|---|
| | really opened my eyes about the usage and reliance on fossil fuels. I think the goal for BWL's clean future is very bright and progressive, but I wish it has more haste! I understand the need for a smooth transition, but time is running out, and I think a more intensive clean energy plan is needed. On a side note, I have always been pleased with BWL's service, I have been a utility customer for over 2 years and never had an issue. Thank You! |
| **Low-Cost** | Very cool set up, with lots of valuable information and helpful staff. |
| **Resiliency** | I feel that future needs should take a closer look at waste to energy options and small nuclear systems (storage shed size). |
| **Environmental** | I think the primary focus should be on getting to 100% renewable power as quickly as possible. |
| **Reliability** | We need to be able to trust our energy system. we also need to understand what costs are coming and what will be needed from us. this program was very helpful and interesting. Thank you for taking the time. |
| **Reliability** | Thanks for conducting these community engagement sessions. Here are three areas that I think merit consideration in the current IRP process:<br><br>1. Sensitivity to long-term natural gas prices. There is growing evidence that domestic gas production will not meet U.S. EIA long-term price projections, and growing demand pressure will continue from a combination of factors including tighter competition among electric utilities and rising LNG exports. Please study this sensitivity with great care.<br><br>2. More financing for deeper energy retrofits for all customer sectors. How can on-bill financing and other tools provide bundled financing options? Energy savings remains a valuable resource for BWL customer-owners and the more of it we can tap, the better.<br><br>3. Develop more programs to leverage water efficiency for energy savings. Lansing is fortunate that its hometown utility also serves as its water utility. Having both services under one company allows for greater coordination between water and energy efficiency programs than is usually possible. This presents a great advantage.<br><br>Again, thanks for your community outreach. |
| **Reliability** | |
| **Reliability** | |

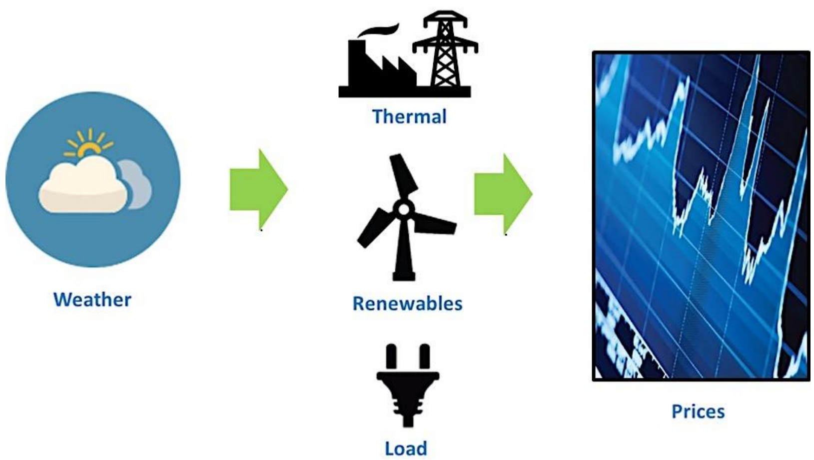
# Appendix B: Demand Side Management Potential-(*Separate Attachment)*

# Appendix C: Ascend Analytics

## PowerSimms Model description

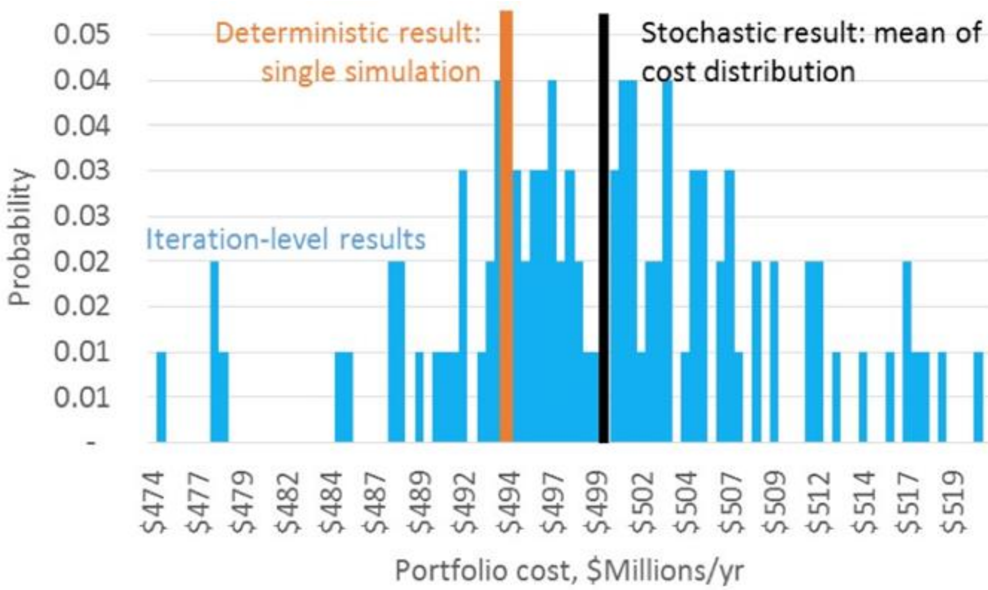
PowerSimm is a dispatch optimization and production cost tool. The tool is comprised of two major elements, the Sim Engine and Dispatch Optimization, that work together to systematically bridge the physical and financial dimensions of electricity provision. PowerSimm uses a simulation-based approach born of the best-in-class techniques to perform decision analysis for portfolio risk management. In that world, managing risk requires characterization of the volatility in fuel price, power price, renewable generation, and outages. PowerSimm adopts this paradigm into the resource planning context.

### *PowerSimm's Sim Engine Captures "Meaningful Uncertainty" in weather, load, renewables, and prices*




The simulation of uncertainty with respect to weather is becoming ever more critical because "weather is the new fuel" in the emerging high-renewables system. To capture the changing market dynamics with renewables, PowerSimm simulates weather to capture its effect on renewable output and its effect on energy price formation. We call this "characterizing meaningful uncertainty." It is not simply noise around an arbitrary base scenario, but realistic paths of weather driving renewables, loads, and prices. That means PowerSimm is performing dispatch against system conditions as they really exist, not the idealized system modeled by traditional production cost models. PowerSimm is a stochastic construct and through 100 or more simulations, or "sim-reps," we probabilistically envelop all possible future states through a coherent and appropriately correlated set of data inputs and forecasts. Figure C-1 demonstrates the value of PowerSimm's stochastic approach. The orange line represents the result of a single deterministic run, which would have been calculated based on smooth average profiles. PowerSimm generates the blue Sim Reps stochastically, characterizing a full distribution of possible outcomes of portfolio cost. With PowerSimm, resource decision making is supported not only with the mean of the distribution, but also by risk considerations informed by the 5th and 95th percentiles. Therefore, we can solve for the optimal resource portfolio that strikes the best balance between cost and risk.

*Figure C-1: The value of stochastic analysis in resource planning*

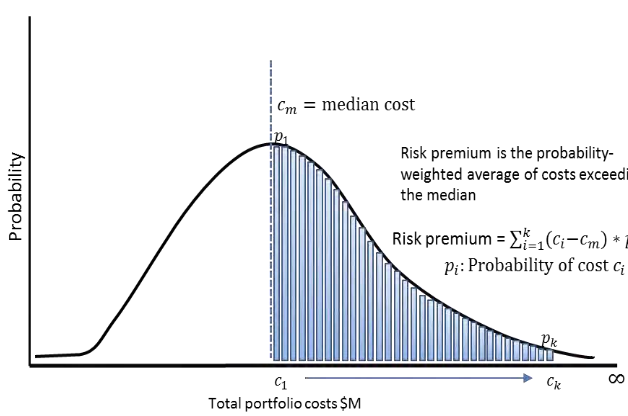



## Using Risk Premium for Resource Decision Making

PowerSimm also identifies the risk associated with each energy portfolio option, quantifying this as the "risk premium." Since different energy portfolios have different simulated cost distributions, the risk premium will be larger for wider cost distributions, or riskier portfolios, and smaller for narrower cost distributions, or less risky portfolios. Ascend then adds the risk premium variable to the expected value to put all energy portfolio options on the same playing field. The factors that drive risk in total portfolio cost include fuel price risk, carbon price risk, and market risk.

The risk premium is defined as the probability-weighted average of costs above the median, and this concept is illustrated below in Figure C-2.

*Figure C-2: Risk premium is an economic concept measuring how prone a portfolio is to higher than expected costs*




PowerSimm planner monetizes risk through applying an actuarial option approach where the value of risk (the risk premium) is calculated as the integral of the cost distribution from the mean to the upper tail of costs, reflecting the downside risk to ratepayers. The underlying distribution of costs follows from production cost modeling with input simulations of market prices and correlated simulations of weather driving both simulated load and renewables. These underlying simulations are developed to satisfy a long set of validation criteria to ensure "meaningful" uncertainty is reflected in the final distribution of costs.

## Automated Resource Selection and Capacity Expansion

*Introduction and Overview of Automatic Resource Selection Model and Capabilities*

Key Take-Aways

- PowerSimm Planner is a sub-package of PowerSimm developed and supported by Ascend Analytics (Ascend) of Boulder, Colorado.
- A trademark feature of PowerSimm Planner is Automatic Resource Selection (ARS) and Capacity Expansion. ARS allows utilities to make long-term resource planning decisions based on least-cost and lowest-risk.
- ARS in PowerSimm uses a stochastic simulation, which allows for the utility to make decisions over hundreds of future scenarios, rather than restricting the decision to a single simulated outcome. This distribution of scenarios provides an understanding of the risk associated with planning decisions.
- ARS optimizes decisions on new generation, repowering, and retirement based on capital and fixed/variable O&M costs to reduce Portfolio Net Present Value. Decisions can be constrained based on a variety of variables, including Renewable Portfolio Standards, market sales/purchases constraints, and Reserve Margin requirements.

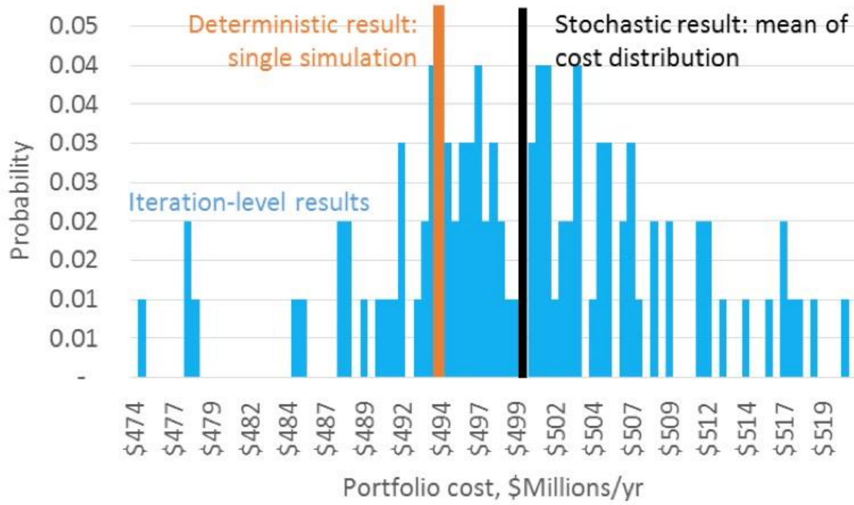
## Introduction

Automated Resource Selection (ARS) is an advanced capability of PowerSimm Planner that uses detailed dispatch modeling to make optimal resource planning decisions by determining the least-cost and least-risk resource options to meet future load and RPS requirements. ARS uses mixed integer programming (MIP) techniques to optimize resource selection decisions, with the objective of minimizing the net present value of capital expenditures and production costs, subject to both physical and financial constraints. While other models have similar algorithms for resource selection, PowerSimm is the only model that solves for the optimal portfolio over hundreds of simulated future states, providing a robust resource plan that will be practical and cost-effective under the widest variety of possible futures.

## Advantages of Stochastics-based Resource Selection

While deterministic models run with various sensitivities may provide insight into resource planning decisions, the limited set of information provided by this method will bias the study results. However, stochastic simulation, in which a wide variety of studies are performed using a distribution of underlying parameters, removes this bias. Figure C-2 reproduced below illustrates this effect by showing how results of a single deterministic study (shown in orange) may differ substantially from the expected value across many stochastic simulations of future conditions (shown by the solid black line). Furthermore, stochastic simulation provides information on the "meaningful uncertainty" of the results, enabling accurate articulation of risk for each of the proposed portfolios.

*Figure C-2. Deterministic versus Stochastic Simulation Based Results*




The use of stochastic simulations can be combined with the Automated Resource Selection module of PowerSimm Planner to systematize the resource selection process. The methodology provides the best supply portfolio overall based on all simulated future conditions. Given a distribution of possible dispatch scenarios based on hundreds of simulations of weather, load, prices, and renewable generation, each planning scenarios can be accurately judged on their associated risk as well as cost. A deterministic model may select the lowest average expected cost, but this may be the most volatile portfolio which introduces significant risk that the utility cannot take on. The ability to select the optimal portfolio over a broad spectrum of future conditions without loss of generation modeling details provides substantial advantages over picking the best portfolio from a single deterministic run.

## Capabilities of Automated Resource Selection

Automated Resource Selection can optimize resource decisions in three primary categories:

- New Generation
- Retirement
- Repowering

Each candidate resource, whether new or existing, is input in full technical detail into PowerSimm to generate accurate simulations of its dispatch and market interactions across all future scenarios. Data from these simulations enables calculation of both the expected revenue generated by this resource as well as the expected marginal costs of operation over the course of its lifetime.

Because resource planning involves a trade-off between long-term capital investment decisions and variable operating costs, the optimal expansion plan seeks to minimize the net present value (NPV) of future capital expenditures and future fixed and variable costs. ARS uses the overnight capital costs and fixed/variable O&M costs to calculate a levelized annual revenue requirement for each candidate resource, thus accounting for any capital investment decisions not fully amortized over the simulated planning horizon.

These calculations are fine-tuned by inputting general economic assumptions such as WACC, inflation, relevant tax rates, and depreciation life of the resource, allowing for accurate discounting of future expenditures and proper depreciation of assets. Please refer to the appendix for a breakdown of the inputs to fixed and variable O&M costs. The projects with maximal value (annualized revenue less annualized cost) are selected for implementation, subject to any imposed system constraints.

One of the key features of ARS is the ability to impose system constraints on the selection of candidate resources into an optimized generation portfolio. Typically, these constraints may include:

- Renewable Portfolio Standards (RPS)
- Market Sales/Purchase Limits (Energy and Capacity)
- Reserve Margin Requirements.

This feature allows the user to input all the available candidate resources and let ARS add, retire, or repower the resources that will most efficiently meet these constraints and minimize capital requirements of the portfolio.

Once the optimal resource portfolio is established, ARS can also determine an optimized build schedule for all candidate resources. If a candidate project has a pre-determined implementation date, ARS can easily make the decision of whether that project is economically viable if it comes online at that time. However, if the plans are more flexible and a resource may come online in a range of time, ARS can calculate when in that time range is optimal for serving both load and economic value and automatically select an optimized start date.