

AGENDA

**SPARTA TOWNSHIP
PLANNING COMMISSION
Tuesday, March 10, 2026
7 P.M.**

**Sparta Township Hall
160 East Division Street
Sparta, MI 49345**

This meeting can be viewed live or recorded at
<https://www.youtube.com/channel/UCu9bOagfR6m02k7rdmX3TLA>

- I.** Call to Order
- II.** Pledge of Allegiance
- III.** Additions or Corrections to Agenda
- IV.** Minutes of January 13, 2026, Regular Meeting
- V.** Public Comment (for items on the agenda)
- VI.** Business Items
 - A. Master Plan Review and Adoption
 - B. Data Center Regulations Review
 - C. Home Occupation Regulations Review
- VII.** Public Comment (for items on or not on the agenda)
- VIII.** Staff and Commissioner Comments
- IX.** Adjournment

**Minutes of the Sparta Township Planning Commission
Regular Meeting of Tuesday, February 10th, 2026, 7PM
Sparta Township Hall, 160 E Division ST., Sparta MI**

This meeting can be viewed live or recorded at <http://www.youtube.com/channel/UCu9bOagfR6m02k7rdmX3TLA>

Present: Chairperson Terry Hartman (9/28), Vice Chairperson Tim Driscoll (9/28), Commissioners Don Doyle (9/27), Ken Humphreys (9/27), Secretary Linda Anderson (9/28) and Township Board Trustee Barb Johnson (12/28).

Also Present: Zoning Administrator/Planner Kevin Yeomans of Fresh Coast Planning, Sparta Township Supervisor Dale Bergman, and recording Secretary Sarah Fischer.

Absent: Commissioner Dale Flanery (9/27)

I./II. Call to Order / Pledge of Allegiance: Chairperson Hartman called the meeting to order at 7:00 PM, followed by the Pledge of Allegiance.

III. Additions or Corrections to the Agenda: Motion by Johnson, second by Discoll to approve the Agenda as written. Motion carried unanimously.

IV. Minutes of January 13, 2026, Regular Meeting: Motion by Doyle, second by Humphreys to approve the Minutes. Motion carried unanimously.

V. Public Comment (for items on the Agenda):

Brooks Burg of 10870 Phelps Rd. emphasized his concern that the proposed data center project represents "too much, too fast, too soon." He reminded everyone that township citizens and voters are calling for a moratorium on data centers while the community takes time to learn more about their potential impacts.

VI. Business Items:

A. Public Hearing – Moratorium Amendment

No public comments were received, the public hearing was closed, and the Commission moved into deliberation. The Planning Commission reviewed a proposed zoning ordinance amendment intended to streamline the process for adopting future moratoriums based on legal counsel's recommendation to better address rapidly evolving technologies. Johnson made the motion to recommend that they adopt the moratorium ordinance as presented to the Township board, second by Doyle. Motion carried unanimously.

B. Public Hearing – Master Plan Review Adoption & Accessory Dwelling Unit

Regulations No public comments were received, the public hearing was closed, and the Commission moved into deliberation. The Planning Commission reviewed proposed

updates to the Master Plan, including clarifying language for the Mixed Use Residential Commercial designation. The revisions maintain the original intent but remove reference to a specific development method, allowing flexibility through future zoning ordinance updates.

Discussion centered on the commercially zoned strip along Sparta Avenue, where several existing homes are legally non-conforming. Concerns were raised about limitations on rebuilding or expanding these properties. The Commission agreed that revisions to the future land use map and related text were needed to better reflect the corridor's mixed residential and commercial character. Johnson made a motion to table the discussion until the Master Plan is updated with the proposed revisions. The motion was supported with all members in favor.

C. Accessory Dwelling Units

The Commission also revisited proposed amendments to the Accessory Dwelling Unit (ADU) regulations. The revisions require Special Land Use approval and limit occupancy to the property owner and family members. Johnson made a motion to accept the amendments as written. The motion was supported with all members in favor, and the Commission is forwarding the recommendation to the Township Board for consideration.

D. Data Center Regulation Review

The Planning Commission began initial discussions on a proposed zoning ordinance amendment addressing data centers. Legal counsel prepared a draft ordinance that outlines key considerations such as power and water usage, emergency preparedness, decommissioning requirements, and financial guarantees.

Commission members provided preliminary feedback and identified additional areas for research and potential regulation, including but not limited to:

- Minimum lot size and increased setbacks
- Generator placement and noise standards
- Screening, landscaping, and architectural design requirements
- Distance from schools
- Impacts on farms, livestock, and pollinators
- Clear definitions distinguishing small-scale facilities from large "hyperscale" data centers
- Classification as industrial vs. commercial uses
- Infrastructure and potential legacy costs to the Township

Public comment raised concerns about allowable noise levels and recommended stricter standards. The discussion focused on gathering direction and research topics before further refining the ordinance. Staff will continue reviewing best practices from other

communities, participate in upcoming training/webinars, and return with additional information and recommendations.

VII. Public Comment (for items on or not on the agenda): None

Brooks Burg of 10870 Phelps Rd. raised concerns about potential **electromagnetic field (EMF) impacts** associated with data centers, including effects on electronics, people, and nearby animals.

VIII. Staff and Commissioner Comments

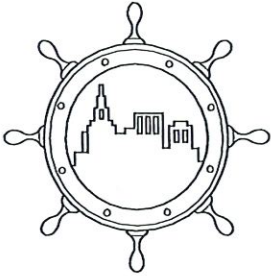
Land Division Act Amendment

Kevin provided an update on the upcoming Land Division Act changes effective March 2027. The amendments will allow more lot splits, particularly affecting A2 and R1 districts, while minimum lot sizes in A1 remain unchanged. Larger private roads may be required for parcels with multiple splits, and additional guidance from legal counsel and the Michigan Townships Association is still pending.

The Planning Commission's worklist includes 15 items, with priorities such as home occupation regulations, duplexes, master plan updates, and data center rules. Other key areas under review include zoning clarifications, setbacks, stormwater standards, solar and battery regulations, and private road requirements, with a broader zoning ordinance restatement planned to streamline and simplify processes.

IX. Adjournment: Motion to adjourn at 7:59 pm EST by Humpheys, second by Anderson. The motion passed unanimously, with all members in favor.

Submitted by: Sarah Fischer



Fresh Coast Planning

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Kevin Yeomans

Alexis Gulker

Aaron Bigelow

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Andrea Goodell

MEMORANDUM

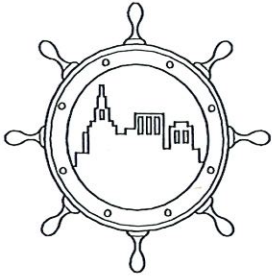
To: Sparta Township Planning Commission
From: Kevin Yeomans
Date: 3/4/2026
Re: Master Plan Update

We are working with to finalize removing the Commercial/Industrial Classification from the Master Plan Map and Text. We will return with these updates and a resolution of adoption for review at your next meeting.

Kevin Yeomans
Kevin Yeomans

Planner

CC: Dale Bergman, Township Supervisor



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MEMORANDUM

To: Sparta Township Planning Commission
From: Kevin Yeomans
Date: 3/4/2026
Re: Data Centers – Items for Review

As the Planning Commission is aware there are several items to consider when preparing regulations for a data center. With growing concerns about data across the state of Michigan, we are working to gather information for the Planning Commission to review. This memorandum is intended to provide a high-level overview of the information we have gathered so far.

Attached to this memorandum are an article from the University of Michigan, a study from the University of Sydney, an article from the Brookings Institute and a draft data center ordinance prepared by Sparta Township's legal counsel.

We seek the Planning Commission's direction on how you would like to proceed and if there are any concerns you would like further addressed.

Summary

It appears that the sample provided by legal counsel covers many, if not all, of the major impacts a data center can have. However, the Planning Commission should review the sample and determine if any changes should be made to best fit Sparta Township.

As currently proposed data centers will only be allowed in the Industrial District as a special land use. Any proposed data center would have to meet both the specific standards listed in the provided sample, but also the general review standards listed in Section 154.162 – Standards for Review and Approval [of a site plan] and Section 154.186 – Standards for Consideration [of a special land use].

Scale

Data Centers can take different forms and sizes, ranging from a small data center located in the basement of an existing office building to, what the Michigan Township's Association is calling, a "Hyperscale" facility that can take up hundreds of acres of land. Regardless of size there are common concerns that a community may want to address, such as electricity usage, water usage, fire and emergency services capabilities, noise, lighting, and impact to surrounding land uses.

In the following sections, we provide a summary of many of these items.

Electricity Usage

One concern that we have heard from many of our communities is a data center's impact on utility rates. From research conducted by the Michigan Townships Association (the "MTA"), the data gathered from other states is mixed. In some areas utility rates have risen, in other areas rates have lowered. Given that data centers are not the only variable impacting utility rates, they may not be the only contributing factor to these rate changes.

As you may know, utility rates in Michigan (the "State") are set by Michigan Public Service Commission (the "MPSC"). Additionally, current tax incentives offered by the State require data centers to pay for the improvements necessary for a data center. The MTA has stated

that a Township can still require the applicant to provide proof that their proposed project will not have a detrimental effect on residents' electricity rates. Before including any regulations regarding utility rates, we recommend consulting with the Township's legal counsel.

While the sample provided by Sparta Township's Legal Counsel covers many items, it does not appear to require any utility rate study or other documentation to provide for an application for a data center.

To give some perspective on how much energy a hyperscale data center may need, we have provided the following examples:

- The data center facility in Saline Township is projected to need 1,400 MW of electricity.
- 1,000 MW of electricity can serve approximately 800,000 homes.
- As shared by the MTA, a currently proposed 8,000-acre solar farm is projected to generate 800 MW of electricity.

Water Usage

From our research there are three main types of cooling systems that are used for data centers: evaporative cooling, closed-loop cooling, and air cooling. At this time, we have found many articles that speak to the different cooling methods but are not confident that the articles we have found so far are unbiased. Below we provide a summary of our current understanding of these three cooling methods.

Regarding cooling methods, the amount of water needed has an inverse relationship with the amount of electricity needed. Evaporative cooling requires a large, or even massive, amount of water depending on the scale of the data center but also has the lowest need for electricity. Closed-loop cooling requires a large amount of water to start, but only minimal water once the system is up and running. Air-cooled systems do not require any water but have a much larger need for electricity. There are also hybrid systems that combine different cooling methods.

The Township can require hydrogeological and other studies to ensure that a data center can either be efficiently served by an existing public water system or that the aquifer is able to support the use without negatively impacting other wells. Further, the Township can place restrictions or requirements on the type of cooling used. It is our understanding that some communities are looking at restricting cooling systems to air-cooled only.

Subsection C(14) of the sample regulations provided by legal counsel requires an applicant to provide proof of environmental compliance. This subsection references different state laws with which we are not completely familiar. It is likely that these laws would require an applicant to provide hydrogeological and other studies to show the impact to the aquifer and other bodies of water, but further research is needed for us to fully advise the Planning Commission.

Fire and Emergency Response

Data Centers regardless of size can present unique challenges in terms of fire and emergency response. For this reason, it would be prudent to require data centers to provide hazardous waste management plans and fire protection plans for review and approval by the Township. If a local fire department is unable to safely serve a proposed facility, that can be grounds for denying a project. Additional details are provided in the off-site improvements section of this memorandum.

The sample provided by Sparta Township's legal counsel covers these requirements in subsections C(10) and C(11).

Decommissioning

As the Planning Commission is aware, technology is rapidly evolving and concerns regarding the impact of when a data center closes is at the forefront of many communities when reviewing these uses. Requiring a financial surety (noncancelable bond, irrevocable letter of credit, escrow) is a common and effective tool used for similar projects such as sand mines and large-scale renewable energy projects. We recommend that all communities have express regulations in place for how the amount of a financial surety is set.

The sample provided by legal counsel covers decommissioning and financial security in subsection B(7), C(13), C(14).

Noise

Another common concern is the amount of noise generated by data centers. Similar to industrial uses, operations for a data center can be expected to generate noise both from their 24/7 operations, but also from the backup generators designed to serve them during a power outage.

While the sample provided by legal counsel limits noise levels to 45 dBA maximum at the property lines, the Planning Commission could consider other restrictions or requirements, such as require noise monitoring devices to be installed or requiring a noise study to be conducted and not allowing an increase in existing dBA at the property lines. So you are aware, 45 dBA is equivalent to a library or a suburban area at night.

Lighting

Security for data centers is expected to be a priority. With this expectation in mind, lighting could have a potential adverse impact. Similar to commercial and industrial uses, a photometric plan can be required to show that the lighting used will not illuminate past the property lines.

The sample provided by legal counsel states that the lighting used will be the minimum light necessary for safe operation and shall not exceed beyond the perimeter of the lot. The Planning Commission may consider other restrictions as to the type of lighting used: dark-sky friendly, full cut-off, etc.

If the Planning Commission considers restricting the type of lighting used, we recommend a full review of lighting requirements to ensure that all uses are regulated equally.

Impact on Bees

Given the agricultural character of the Township and the importance of bees to fruit farmers in the area, the Planning Commission directed us to find more information regarding data center impacts to bees.

We were able to find many articles that spoke about the potential impacts to bees. All of which referred to a study completed by the University of Sydney's Centre for AI. A copy of "*The Digital Climate Footprint: From Global Data Centre Growth to Local Ecological Consequences*" has been attached for your review.

Our understanding of the study's findings is that the identified danger to bees is not a direct impact from data centers. It appears that the danger would come indirectly from data centers power consumption, which will require additional power to be generated. The additional power generated could require power plants to increase their CO2 emissions, which would then drive increased temperatures. With bees being sensitive to temperature changes this could increase the rate of hive failure rates.

Given the findings of the study, we are not sure how, or if, the Township is able to regulate this potential negative impact.

Electromagnetic Fields ("EMF")

We have not been able to dedicate much time to reviewing the potential impacts of EMF. From the articles we have reviewed, including articles from the National Cancer Institute and the National Institute of Environmental Health Sciences, it appears that low-level, everyday exposure to EMF does not appear to cause long-term health risk, but acute, high-level exposure may have potential links to cancer or other health issues. Given that this is well outside of our expertise we may not be able to fully advise the Planning Commission regarding these concerns. If the Planning Commission wishes us to further review this matter, we are happy to do so.

National Cancer Institute. (n.d.) Electromagnetic Fields and Cancer. Retrieved 3/3/2026, from <https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/electromagnetic-fields-fact-sheet>

National Institute of Environmental Health Sciences. (n.d.) Electric & Magnetic Fields. Retrieved 3/3/2026 from

<https://www.niehs.nih.gov/health/topics/agents/emf#:~:text=IARC%20Classifies%20Radiofrequency%20Electromagnetic%20Fields%20as%20Possibly,brain%20cancer1%2C%20associated%20with%20wireless%20phone%20use.>

Other Emissions

At this time, we are not aware of any other data center emissions that the Planning Commission may want to consider.

Off-Site Improvements

There are legal limits that must be considered when determining whether off-site improvements are necessary as part of the review of a proposed use.

First, the Planning Commission must have competent evidence that the improvements are necessary as a result of the project. For example, if the Planning Commission determines that road improvements are necessary there needs to be evidence that improvements needed are a direct result of the traffic that is expected to be generated by the proposed use. This is usually accomplished by requiring an applicant to provide trip generation analysis, traffic studies, or other similar studies.

Second, once there is proof that offsite improvements are necessary, the Planning Commission cannot require an applicant to pay for these improvements. However, it is our understanding that a municipality cannot be forced to extend roads or utilities. Given this, while it is possible that a municipality will take on some, or all of the cost, of improving a road or utility, it is more often the case that if an applicant wants to proceed with a project that requires improvement to a public road or utility, they must enter into an agreement with the municipality which requires the applicant to bear the cost of the necessary improvements.

Host Community Agreements

As you'll see on page 18 of the attached article from the University of Michigan, there is a tool sometimes called a "Host Community Agreement" or "Host Community Benefit Agreement" which an applicant can voluntarily offer as part of their application. However, there are limitations in enforcing these agreements. If an applicant does offer a host community agreement, the Township should also offer a tax abatement or other public-funded improvement in order to better tie the applicant to their offer.

Economic Impact

Guidance from the MTA indicates that a hyperscale facility, even with the currently provided tax incentives from the state, can provide significant tax increases for a community. The tax impact of smaller-scale data centers will need to be reviewed on a case-by-case basis by the Township Board.

Short-term job creation

In the short term a data center can create a large number of jobs related to the construction of data centers. However, similar to large industrial uses, the contractors used are not always local, or sometimes even headquarters within the State. These jobs are unlikely to create a long-term economic impact for a community.

Long-term job creation

In the long-term data centers can provide a considerable number of jobs, based on the size of the data center. However, these roles tend to be specialized. If the local workforce does not have the training necessary to fill these roles it is unlikely that a data center will have a major impact on local job creation. It is our standing that long-term job creation tends to have a regional impact. This does not mean that a data center cannot have a long-term impact on jobs, but that in order to capture the potential benefits requires a community to have a broader long-term economic plan.

A February 5, 2026, article from the Brookings Institute (attached) provides more details on both short and long-term job creation.

At this time, we have no further items to bring to the Planning Commission's attention.

Kevin Yeomans
Kevin Yeomans

Planner

Attachments

CC: Dale Bergman, Township Supervisor



WHAT MICHIGAN LOCAL GOVERNMENTS SHOULD KNOW ABOUT DATA CENTERS

February 2026



GRAHAM SUSTAINABILITY INSTITUTE
CENTER FOR EMPOWERING COMMUNITIES
UNIVERSITY OF MICHIGAN

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Background & Purpose

While data centers have operated in Michigan for some time,¹ they have largely existed without debate or public scrutiny. With the growth of AI and cloud computing, however, demand for larger, more resource-intensive data center facilities has surged. Following the recent expansion of state-level tax incentives for data centers, developers have begun looking to Michigan to identify new siting opportunities for significantly larger facilities.

Much has been written about the opportunities and risks that AI and data centers pose to society at large.² **This guide is not intended to resolve or mediate this society-wide debate; instead, it focuses on local-level considerations.** Like all land uses, data centers bring both positive and negative local impacts to the communities that host them. These impacts can vary depending on the specific technology used within a data center, the state regulations that shape its development, and its location within the host community. For example, there is a trade-off between the amount of water and energy a data center consumes, which depends heavily on the cooling technology used. State and local policy can also shape data center impacts on water and energy, as well as the direct economic impacts on the host community, including property taxes and job creation.

This guide is intended to provide Michigan local government officials and planners, particularly those with zoning authority, with the information they need to effectively participate in data center siting conversations. The first section of this guide provides a basic introduction to the environmental and economic impacts of data centers and links them to the current Michigan policy context. In the second section, we offer planning and zoning recommendations applicable not just to data centers but to a range of industrial land uses. Wherever possible, we draw on lessons from data center development in other states and from other industrial development, including our own expertise with large-scale renewable energy projects. **Since policies, technologies, and best practices for data center siting are rapidly evolving, readers should treat this guide as a working document. We plan to revise it or add supplementary guides as we learn more.**

¹ Estimates range on the number of data centers currently in Michigan, likely due to the broad definition of what constitutes a data center. The U.S. Department of Energy's Office of Scientific and Technical Information's Data Center Atlas lists nine data centers in Michigan. Recent local reporting has noted approximately 44 data centers in the state. Mongird, K., Thurber, T., Vernon, C., Burleyson, C., Akdemir, K. Z., & Rice, J. (2025). *Im3 open source data center atlas*. Pacific Northwest National Lab (United States). <https://doi.org/10.57931/2550666>; *Your guide to Michigan's data center boom—And the growing backlash*. (2025, November 18). WKAR Public Media. <https://www.wkar.org/wkar-news/2025-11-17/your-guide-to-michigans-data-center-boom-and-the-growing-backlash>

² *Data centers are amazing. Everyone hates them*. (n.d.). MIT Technology Review. Retrieved February 5, 2026, from <https://www.technologyreview.com/2026/01/14/1131253/data-centers-are-amazing-everyone-hates-them/>; Copley, M. (2025, October 14). Data centers are booming. But there are big energy and environmental risks. *NPR*. <https://www.npr.org/2025/10/14/nx-s1-5565147/google-ai-data-centers-growth-environment-electricity>

Data Center Basics

A data center is any physical room or facility that houses information technology infrastructure. Many data centers provide computing services that keep websites running, enable video streaming, and support the software used by banks, hospitals, and human resources departments. With the rise of technologies such as cloud-based services and the Internet of Things (e.g., “smart” appliances, building systems, and other equipment that send data and can be controlled via the internet), we have seen the construction of newer, larger data centers to accommodate these increasingly popular technologies.³ In particular, the advent of generative artificial intelligence (genAI) and large language models (LLMs) has driven the development of very large data centers.

A data center’s infrastructure includes not just the servers (i.e., computers) that store and process information, but also networking equipment to get information to and from the internet, power supply equipment to protect the computers against fluctuations in electricity, and environmental control equipment to cool and maintain humidity.⁴ The graphic on the next page includes a useful depiction of the components of a data center.

While a data center supporting a small business’s operations, for example, may be as small as a closet, most of the current attention – and the rest of this guide – focuses on large, “hyperscale” data centers. Hyperscale data centers house over 5,000 servers, and have a footprint ranging in size from 10,000 to millions of square feet.⁵ Generally, the digital services enabled by hyperscale data centers benefit a national or multi-region customer base rather than just the community or business property where the facility is located.

Data center companies choose sites for new development based on a variety of factors. In addition to needing to find a site with enough land to house the data center, they also require sites near an electric transmission line with sufficient capacity to provide power to the facility and high-capacity, low-latency fiber-optic cable to connect to the internet.^{6 7} If the data center plans to use water for cooling, it must also be sited near an adequate water source. From a financial perspective, developers are also more likely to build new facilities in localities that offer tax exemptions or other financial incentives.

³ Center for Sustainable Systems, University of Michigan. 2025. "Artificial Intelligence Factsheet." Pub No. CSS25-22. <https://css.umich.edu/publications/factsheets/built-environment/artificial-intelligence-factsheet>

⁴ *What is a data center?* | *ibm*.

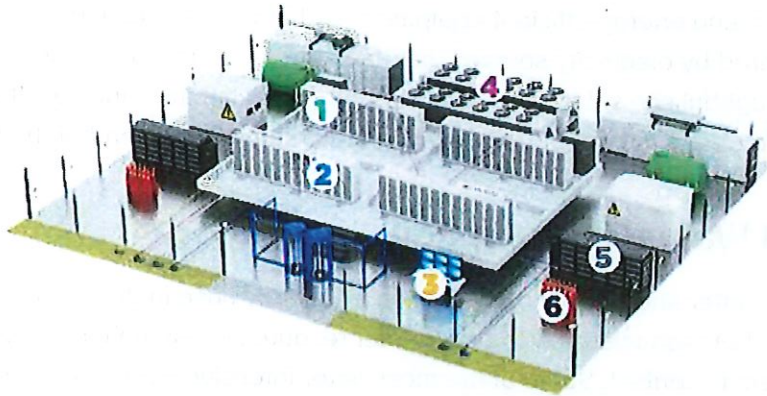
⁵ *What is a hyperscale data center?* | *IBM*. (2024, March 21). <https://www.ibm.com/think/topics/hyperscale-data-center>

⁶ CallisonRTKL, R. B., Vice President and Director, Mission Critical Group. (2015, January 19). *Parameters to consider in the data center location decision*. Area Development. <https://www.areadevelopment.com/data-centers/data-centers-q1-2015/data-center-location-decision-parameters-46734866.shtml>

⁷ A recent trend in hyperscale data center development is for hyperscalers to build their own privately-owned, low-latency fiber networks if their preferred site lacks reasonable access to backbone fiber. Datacenters.com. (2025, September 3). *Who’s Building the Next 200MW Colocation Campuses—And Why?* . <https://www.datacenters.com/news/who-s-building-the-next-200mw-colocation-campuses-and-why>

Components of Data Centers

Data centers consist of several [critical components](#) that ensure efficient operation and reliability.



Source: <https://datacenterdiversity.com/resources/data-center/> To view this interactive graphic visit the Data Center University website

1 Servers

The backbone of data processing and storage, servers are computers connected together to run applications and computing tasks.

2 Storage Systems

Data centers house vast amounts of digital information, stored on solid-state drives or hard disk drives.

3 Networking Equipment

Includes routers, switches and firewalls that manage data traffic and security.

4 Cooling Systems

Prevent overheating by using air or liquid cooling methods to maintain optimal operating temperatures for computers.

5 Power Infrastructure

Includes backup generators and uninterruptible power supplies to ensure continuous operation.

6 Security Systems

Physical and cyber security measures such as biometric access controls, surveillance cameras and fire suppression systems.

Source: [National League of Cities](#)

Environmental Impacts and Michigan Policies

This section details a summary of key environmental impacts; generally, the most environmentally-friendly data centers are those that:

- Use water- and energy-efficient equipment and practices within the data center
- Are powered by electricity sources that have low water use and reduced emissions⁸
- Have thoughtful site selection that avoids important habitats and sensitive lands
- Commit to decommissioning - removing infrastructure at the end of the facility's useful life

Energy and Water Consumption

Questions about water and energy consumption frequently arise in data center discussions. Because the numbers associated with data center resource consumption are so large, it may be helpful to put them in context. Some of the most water-intensive hyperscale data centers, for example, can require up to five million gallons of water per day.⁹ Putting this into perspective within Michigan's context, the Great Lakes Water Authority's five freshwater treatment plants have maximum rated capacities between 240 and 540 million gallons per day, and currently have an estimated combined maximum demand of 1 billion gallons per day.¹⁰ Using an example within the context of Michigan's energy consumption, the proposed data center in Saline Township would require 1,400 megawatts of power capacity. By comparison, the state's total generation capacity in 2024 was just over 32,000 megawatts.¹¹

Energy and water consumption are presented here together because they are linked. While there is currently a gap in publicly available data on energy and water use by specific computing and cooling technologies,¹² we do know that there is typically a trade-off between energy and water use. Technologies like evaporative cooling are more energy-efficient but more water-intensive. Meanwhile, air-cooled or closed-loop chillers use minimal to no water, but are energy-intensive.¹³ Both types of cooling systems are common, and often the developer may choose between them based on availability of water and cost; the water-efficient closed-loop systems are currently more costly than open-loop evaporative cooling.¹⁴ As noted in this document's state-level tax abatement section, the sales and use tax exemptions for "enterprise" data centers, which were

⁸ Xiao, T., Nerini, F.F., Matthews, H.D. *et al.* Environmental impact and net-zero pathways for sustainable artificial intelligence servers in the USA. *Nat Sustain* 8, 1541–1553 (2025). <https://doi.org/10.1038/s41893-025-01681-y>

⁹ Wroth, K. (2025, October 17). *Data drain: The land and water impacts of the ai boom*. Lincoln Institute of Land Policy. <https://www.lincolnst.edu/publications/land-lines-magazine/articles/land-water-impacts-data-centers/>

¹⁰ GLWA 2022–2026 CIP Appendix D: System Background Information. (n.d.). Great Lakes Water Authority. https://www.glwater.org/wp-content/uploads/2020/12/GLWA-2022-2026-CIP_AppendixD.pdf

¹¹ <https://www.eia.gov/electricity/state/michigan/>

¹² Shehabi, A., Smith, S.J., Hubbard, A., Newkirk, A., Lei, N., Siddik, M.A.B., Holecek, B., Koomey, J., Masanet, E., Sartor, D. 2024. 2024 United States Data Center Energy Usage Report. Lawrence Berkeley National Laboratory, Berkeley, California. LBNL-2001637. <https://escholarship.org/content/qt32d6m0d1/qt32d6m0d1.pdf>

¹³ Google's Water Risk Framework Assessing watershed health in data center communities. (2023, December).

¹⁴ *Chilling out: Data centers find new ways to reduce cooling costs | news & insights*. (n.d.). Gray. Retrieved February 4, 2026, from <https://www.gray.com/insights/chilling-out-data-centers-find-new-ways-to-reduce-cooling-costs/>

signed last year, include requirements related to water and energy. However, these same provisions are not required for the “qualified” data center exemption category, which has been available since 2015.

When thinking about a data center’s sustainability, something to note is that even in data centers that have minimal *direct* use of water for cooling, there may still be *indirect* use of water. That is because most U.S. power plants are thermoelectric¹⁵ and require significant amounts of water to operate.¹⁶ This indirect water impact is no different from that of other high-demand electricity users, and can be minimized when data centers are located in electricity grids that have less reliance on thermoelectric power plants or when the data centers themselves are powered by electricity sources that do not require water for operations (e.g., wind and solar power). Consequently, this water use is rarely in the community hosting the data center, but rather in communities that host power plants that supply electricity to the grid. While Michigan’s electricity fleet has been reducing its reliance on thermoelectric power plants as it adds renewables to the grid, in 2024, Michigan’s electric power plants withdrew roughly 5.4 billion gallons of water per day for power plant cooling.¹⁷

Like the federal government, Michigan does not have policies specifically governing data center energy use.¹⁸ However, the Michigan Public Service Commission (MPSC, also known as the Commission) regulates several policies relevant to data centers. Primarily, the MPSC regulates both the investor-owned utilities that charge data centers for electricity and natural gas and the terms of service under which those utilities operate. The Commission also requires all entities that provide electricity to customers in Michigan, including investor-owned utilities, cooperatives, municipal utilities, and alternative electric suppliers, to prove each year that they have adequate resources planned four years ahead to meet their customers’ electricity needs.¹⁹ Furthermore, the Commission has the power to require additional customer protections in special contract requests submitted by investor-owned utilities seeking to work with data centers, and to attach conditions to any approval it grants. However, the Commission cannot control where data centers are built, approve their construction, or issue permits related to their water consumption.²⁰

¹⁵ A thermoelectric power plant uses an energy source (e.g., coal, natural gas, or nuclear) to heat water to create high-power steam which is then used to spin a turbine to generate electricity.

¹⁶ In 2023, data centers directly consumed approximately 17 billion gallons of water in their operations and indirectly consumed 211 billion gallons through their energy use. Sadasivam, N. (2025, November 24). *How to make data centers less thirsty*. Grist. <https://grist.org/energy/how-to-make-data-centers-less-thirsty/>

¹⁷Annual Report of the Great Lakes Regional Water Use Database. (2024). Great Lakes Commission. <https://cms.waterusedata.glc.org/media/2024-Water-Use-Report-FINAL.pdf>

¹⁸There is currently federal guidance (not requirements) on data centers used by the federal government. Offutt, M., & Zhu, L. (2025). *Data Centers and Their Energy Consumption: Frequently Asked Questions*. Library of Congress. <https://www.congress.gov/crs-product/R48646#fn59>

¹⁹ *Resource planning*. (n.d.). Retrieved January 4, 2026, from <https://www.michigan.gov/mpsc/regulatory/electricity/resource-planning>

²⁰ *Issue Brief: Case No. U-21990, DTE Electric’s Application for Approval of Special Contracts*. (2025, December 18). Michigan Public Service Commission.

[https://www.michigan.gov/mpsc/-/media/Project/Websites/mpsc/consumer/info/briefs/Issue_Brief_U_21990_DTE_12_18_25-\(002\).pdf](https://www.michigan.gov/mpsc/-/media/Project/Websites/mpsc/consumer/info/briefs/Issue_Brief_U_21990_DTE_12_18_25-(002).pdf)

The MPSC also manages the implementation of Michigan's clean energy standard, legislation that shapes the types of power plants that provide electricity to Michigan utilities.²¹ This law requires utilities to obtain 15% of their power from renewable energy resources each year through 2029, and then 50% in 2030. In 2035, an 80% clean energy standard will take effect, with a target of 100% in 2040. During this transitional period, the MPSC is responsible for reviewing each utility's renewable energy plan to ensure compliance with the standard and for approving cost-recovery mechanisms for regulated utilities. The Commission also has the ability to grant a utility an extension for compliance under certain circumstances.²²

While the MPSC has jurisdiction over the state's utility rates and customer protections, the Department of Environment, Great Lakes, and Energy (EGLE) regulates water withdrawals. Within EGLE, the Geologic Resources Management Division (GRMD) oversees Michigan's regulation of large quantity water withdrawals, with the goal of protecting the state's environment from significant impacts caused by large-volume water consumers. Specifically, Michigan landowners, such as a data center using traditional evaporative cooling, must obtain prior approval before operating pumps capable of withdrawing at least 70 gallons per minute.²³ The permitting process relies on GRMD's Water Withdrawal Assessment Tool (WWAT) for wells or surface water intakes from streams, rivers, or ponds with less than five acres of surface area. GRMD grants approval when no Adverse Resource Impact (ARI) on nearby streams and rivers is determined, resulting in a Water Withdrawal Registration that becomes void if the withdrawal isn't operational within 18 months.²⁴ Further permitting is required in sensitive areas or when large-quantity withdrawal owners seek new or increased withdrawals exceeding 2,000,000 gallons per day (pumps with flow rates of 1,389 gallons per minute or more).²⁵ These regulations apply to any on-site water producers in the state, from agriculture to public water supplies, and would apply whether a data center seeks to withdraw water via a well or if its increased demand would prompt a public water supply to increase its water withdrawals.

In the case of a data center seeking supply through a public water utility, Michigan's Safe Drinking Water Act requires these facilities maintain adequate capacity and reliability for existing customers.²⁶ Further, EGLE will reject water treatment plant construction permits if capacity assessments reveal a proposed expansion or alteration will leave a system with inadequate technical, financial, or managerial capacity to meet requirements.²⁷

²¹ *Clean energy standard*. (n.d.). Retrieved January 4, 2026, from <https://www.michigan.gov/mpsc/commission/workgroups/2023-energy-legislation/clean-energy-standard>

²² MCL 460.1032 (2). <https://legislature.mi.gov/documents/mcl/pdf/MCL-ACT-295-OF-2008.pdf>

²³ *Wwat*. (n.d.). Retrieved October 7, 2025, from <https://www.egle.state.mi.us/wwat/home>

²⁴ *Wwat*. (n.d.). Retrieved October 7, 2025, from <https://www.egle.state.mi.us/wwat/home>

²⁵ *Wwat*. (n.d.). Retrieved October 7, 2025, from <https://www.egle.state.mi.us/wwat/home>

²⁶ Safe Drinking Water Act, Mich. Comp. Laws § 325.1005(1)(e) (1976).

²⁷ Safe Drinking Water Act § 325.1004(2), (7).

Wastewater

Data center cooling systems influence not only water consumption but also the overall quality and volume of wastewater produced. Some cooling systems, like evaporative cooling, can generate wastewater with altered pH, and high concentrations of conditioning chemicals and biocides that are used to reduce the growth of bacteria such as *legionella*.²⁸ While these chemicals are important for minimizing public health risks, they could strain local treatment plants that are not equipped to handle them. Other next-generation data center designs, such as closed-loop and dry cooling, are moving toward minimal or near-zero wastewater discharge.

EGLE's Water Resources Division (WRD) regulates waste or wastewater discharging into the waters of the state. Waters of the state are defined in law as groundwaters, lakes, rivers, and streams, along with all other watercourses and waters, including the Great Lakes. The regulations applicable to wastewater discharges can be divided into three permitting categories: discharges directly into surface water, discharges directly onto the ground or subsurface into the groundwater, and indirect discharges into nearby municipal wastewater treatment systems.

The first category applies to anyone discharging, or proposing to discharge, waste or wastewater into the state's surface waters. This type of permit is required by law under the National Pollution Discharge Elimination System (NPDES) program. This applies to any type of wastewater, including commercial, industrial, and sanitary sewage. The NPDES program is intended to control direct discharge into the surface waters of the state by imposing effluent limitations and other conditions to meet state and federal requirements.

The second category applies to anyone discharging, or proposing to discharge, waste or wastewater directly onto the ground or into groundwater. This type of discharge would require a Groundwater Discharge Permit or an exemption. A groundwater discharge permit imposes effluent limitations and/or groundwater limits set to protect the groundwater for the intended purposes. The intended purposes include protecting nearby drinking water wells, along with groundwater seeping into nearby surface water, to ensure the groundwater is safe for all who use it. This permit type applies to any wastewater, including commercial, industrial, and sanitary sewage. There are other regulating authorities, such as the Local Health Departments, that may become involved through the issuance of construction permits for discharges containing only sanitary sewage generating less than 10,000 gallons per day.

The third category applies to any indirect discharges (those who discharge to a municipal wastewater treatment facility via a sanitary sewer) and does not require an NPDES or groundwater discharge permit. Discharge to a separate storm sewer (i.e., does not go to a municipal wastewater treatment facility) is considered a direct discharge and may require either

²⁸ CDC. (2024, May 8). *Strategies for identifying cooling towers*. Investigating Legionnaires' Disease. <https://www.cdc.gov/investigate-legionella/php/public-health-michigan-strategy/identifying-cooling-towers.html>

an NPDES or a groundwater discharge permit. Discharge to a municipal wastewater treatment facility may require a permit from the municipality under the Industrial Pretreatment Program.

Air Quality

The main air quality impact of data centers stems from emissions associated with electricity production, specifically nitrogen oxides and fine particulate matter (PM_{2.5}).²⁹ Data centers typically draw most of their power from the grid, so the majority of these emissions are generated off-site in the communities hosting the power plants serving the power grid at large. Thus, when data centers are built in regions with cleaner power plants, these air emissions are lower. This impact can be furthered through the adoption of flexible operational strategies, such as load shifting, dynamic scheduling, and participation in virtual power plant (VPP) programs, which can help reduce emissions during peak demand periods. While these strategies are not yet widespread, research indicates that they most effectively reduce emissions when utilized in regions where renewables are already abundant and cost-competitive.³⁰

Even when connected to the grid, data centers have on-site back-up generators, typically fueled by natural gas or diesel, to maintain operations during outages.³¹ Actual emissions at the data center will depend on the number of generators, their size, and permitted runtime hours, and will vary based on individual data center operational standards. In Michigan, EGLE's Air Quality Division (AQD) requires air use and installation permits for equipment emitting air contaminants unless exempted explicitly under Part 2 of the air quality rules (Rules 277-291). While Rule 285(g) exempts the sort of small internal combustion engines that might be used in emergency back-up generators, data centers must also comply with Rule 278, which prohibits using exemptions when total project emissions exceed significance thresholds (e.g., 40 tons/year of nitrogen oxides, 100 tons/year of carbon monoxide, or 10 tons/year of particulate matter 2.5 micrometers or smaller). If aggregate emissions from all back-up generators exceed these thresholds, individual engine exemptions become invalid, and the site must obtain a permit for the entire fleet of generators on-site and any other air-emitting equipment.³²

Land

As with other land uses, the environmental impact of a data center on its site largely depends on site characteristics, the land management practices used during construction, and what happens to the site at the end of the facility's lifespan.

²⁹ Mitigating the public health impacts of ai data centers. (2025, November 5). *Harvard Business Review*. <https://hbr.org/2025/11/mitigating-the-public-health-impacts-of-ai-data-centers>

³⁰ Tran, T. (2025, October 29). Flexible data centers and the grid: Lower costs, higher emissions? -. *CEEPR*. <https://ceep.mit.edu/flexible-data-centers-and-the-grid-lower-costs-higher-emissions/>

³¹ *A primer for local governments: Understanding data centers*. (2025, April). National League of Cities. <https://www.nlc.org/wp-content/uploads/2025/04/Data-Centers-Fact-Sheet.pdf>

³² Insights from Liesl Clark, Director of Climate Action Engagement at the University of Michigan

Data centers may cause environmental harm if sited in areas with sensitive natural features, such as steep slopes, wetlands, floodplains, and unique habitats. Construction activities, such as grading or heavy equipment use, can lead to soil compaction, topsoil removal, and changes in natural water flow, which can hinder the site's future plant growth and water-holding capacity.³³ Furthermore, if infrastructure is abandoned at the end of the project's life, it may result in the creation of a brownfield or make future redevelopment challenging. Such impacts, however, are not unique to data center development, and there are already state and local policies in place to address these common concerns with other industrial developments.

Sometimes there is a concern about whether data centers will impact other land uses, for example, by converting agricultural land. Even if many data centers are constructed, at the national- or state-level, they are only expected to be a minuscule fraction of total land area.³⁴ At the local level, however, there could be noticeable impacts if multiple large data centers are built in close proximity, or if data center development is combined with land-use changes from other sectors (e.g., housing development, energy infrastructure).

Quality of Life

In addition to direct impacts on land, data centers can raise several quality-of-life concerns for neighboring properties. Drawing on lessons from data centers in both Loudoun County, Virginia's "Data Center Alley," and Linn County, Iowa, we have learned that many of these issues can be mitigated through attentive siting.

Many quality-of-life concerns arise from other similar types of industrial development. Construction activities, for example, often have exceptionally high levels of disruption for neighbors, with heavy truck traffic, construction-related noise, and dust.³⁵ When foundations are being constructed, the developers may need to dewater, raising concerns of temporary impacts on local water tables or soil erosion.³⁶ As with other construction activities, soil erosion permits issued by the county or municipality would be required for "any earth change activity that disturbs one or more acres of land or which is within 500 feet of a lake or stream."³⁷ Similarly, when data centers or other industrial activities are developed on previously undeveloped sites,

³³ Augst, T., Fierke-Gmazel, H., Gould, M. C., Krol, M., Mills, S., Neumann, B., Reilly, M., & Stoetzer, O. (2025). *Planning and Zoning for Solar Energy Systems: A Guide for Michigan Local Governments* (Updated ed.). Michigan State University Extension, Michigan State University School of Planning, Design and Construction, and University of Michigan Center for EmPowering Communities.

³⁴ *Power Play: The Emerging Powered Land Opportunity* (n.d.) Hines. Retrieved January 5, 2026, <https://www.hines.com/powerful-land/power-play-full-report>

³⁵ *Data Centers in Virginia*. (2024). [Report to the Governor and the General Assembly of Virginia]. Joint Legislative Audit and Review Commission. <https://jlarc.virginia.gov/pdfs/reports/Rpt598.pdf>

³⁶ *\$750m iowa data center's unpermitted wells draw \$20k fine against dewatering contractor | engineering news-record*. (n.d.). Retrieved February 4, 2026, from <https://www.enr.com/articles/61162-750m-iowa-data-centers-unpermitted-wells-draw-20k-fine-against-dewatering-contractor>

³⁷ *Soil Erosion and Sedimentation Control Program (SESC)*. (n.d.). Retrieved February 6, 2026 from <https://www.michigan.gov/egle/about/organization/water-resources/soil-erosion/sesc-overview>

there is a visual change to the landscape. This is apparent not just during the day, but also at night when parking lot and security lighting may create a notable change to the nighttime character of the property.

Other impacts, though, are more unique to data centers. One of the primary complaints of existing data centers in Loudoun County, for example, is the associated noise.³⁸ Unlike many industrial facilities with variable operational patterns, data centers operate continuously, producing consistent noise that can be problematically disruptive for neighboring residents. In particular, Loudoun County found that inaudible low-frequency sounds were a nuisance to some data center neighbors.³⁹

³⁸ *Data Centers in Virginia. (2024)*

³⁹ *Data Centers in Virginia. (2024).*

Economic Impacts and Michigan Policies

The primary draw of data centers as a land use, at both the state and local levels, is the economic activity they generate. There are, however, concerns about whether data centers will increase electricity costs for consumers. Here, we outline the potential economic impacts of data centers and the policies in Michigan that shape them.

State-level Tax Abatements to Attract Industry

Data centers, like other industries, drive economic activity in the states and communities where they are located. This includes, notably, the direct economic impacts of the surge in construction activity and the initial investment in data center equipment. But it also includes indirect economic benefits to the suppliers of the equipment and other materials that go into data centers, as well as induced effects when data center workers spend their wages on goods and services.⁴⁰ While new economic activity in a state expands the tax base and can fund state and local government services, states often reduce certain taxes to attract industry. Today, 36 states have laws approving state tax incentives for new data center development.⁴¹

For the past decade, the state of Michigan has offered a state-level sales and use tax exemption for “qualified” data centers, with new legislation adopted in 2024 aimed primarily at attracting hyperscale or “enterprise” data centers. The policies governing the sales and use tax exemption are from three key pairs of laws:

- Effective December 23, 2015, **PA 251 and 252 of 2015** added Michigan Compiled Law (MCL) 205.54ee and MCL 205.94cc to Michigan’s General Sales Tax Act and Use Tax Act to create sales and use tax exemptions through December 31, 2035, for the sale, use, or consumption of data center equipment for qualified data centers. Under these Acts, a “qualified data center” is “facilities of one or more buildings located in Michigan that are owned or operated by an entity whose primary business is operating a data center for itself and colocated businesses; the entity must also receive 75% or more of its revenue from unaffiliated colocated businesses.” The Acts required the creation of 400 new data center-related jobs by January 1, 2022, and 1,000 by January 1, 2026. Data center-related jobs include “jobs created at qualified data centers, by colocated businesses, and by contractors making improvements to realty that constitute a qualified data center.”⁴²

⁴⁰*DataCenters-JoyceFoundation_2026-01-13_Final.pdf* | Powered by Box. (n.d.). Retrieved February 4, 2026, from <https://virginia.app.box.com/s/8qq2ggbdgwhf4atrorghtrcqsq64wd74>

⁴¹ *An overview of state data center-related tax incentives* | naiop | commercial real estate development association. (n.d.). Retrieved January 12, 2026, from <https://www.naiop.org/research-and-publications/magazine/2024/Winter-2024-2025/development-ownership/an-overview-of-state-data-center-related-tax-incentives/>

⁴² *Notice Regarding Data Center Exemption*. (2016, March 14). State of Michigan Department of Treasury. https://www.michigan.gov/treasury/-/media/Project/Websites/taxes/Notices/Data_center_exemption_notice.pdf?rev=e6f7d971f9bd4eccba3f208b3fe9d862&hash=DF4CBADC90F299058E7F2F3358A823A2

- Effective February 13, 2020, **PA 29 and 30 of 2020** amended MCL 205.54ee and MCL 205.94cc to establish reporting obligations for sales and use tax exemption claims regarding the sale or purchase of data center equipment.⁴³ Under these Acts, persons seeking exemptions in a particular calendar year must file Form 5726 by January 31 of the following year. Form 5726 requires information on the sales or purchase price of all exempt equipment, and any information needed by the Department of Treasury to calculate School Aid Fund revenue loss as a result of tax exemption claims.
- Effective April 2025, **PA 181 and 207 of 2024** amended MCL 205.54ee and MCL 205.94cc to extend the original tax exemption period from 2035 to 2050 (and to 2065 for data centers built on brownfields), and to establish a new “enterprise data center” facility type that must meet more stringent requirements compared to “qualified data centers” to receive tax exemptions.⁴⁴ In August 2025, the Michigan Strategic Fund (MSF) published formal implementation guidelines for the new amendments, including related to clean energy, water, and green building standards.⁴⁵ Since then, several organizations have submitted comments to the MSF Board requesting changes, particularly related to the interpretation of the clean energy requirements, asking for that standard to be applied from the outset of the data center’s operations rather than a future date.^{46, 47}

Table 1 summarizes key features of these incentives. While both incentive categories have job-creation requirements, their other requirements vary considerably. While smaller, non-hyperscale data centers may only meet the definition of a “qualified” data center, many of the current larger data center development proposals may meet both definitions. Notably, while “enterprise” data centers have many more requirements than “qualified” data centers, the certification process provides greater certainty for developers because the certificate is granted by MSF before they purchase the equipment. By contrast, the “qualified” data center incentive is provided by the retailer at the point of sale, but subject to a Treasury audit which introduces some risk that the exemptions may have been invalid. It is difficult to determine which of the two exemptions data center developers will seek.

⁴³ *Notice: Report for qualified data center exemptions - form 5726.* (n.d.). Retrieved from <https://www.michigan.gov/treasury/reference/taxpayer-notices/notice-report-for-qualified-data-center-exemptions-form-5726>

⁴⁴ *Enterprise Data Center Sales & Use Tax Exemption.* (2025, August 26). Michigan Economic Development Corporation. https://www.michiganbusiness.org/globalassets/documents/data-center/enterprise_data_center_information.pdf

⁴⁵ *Enterprise Data Center Sales & Use Tax Exemption.* (n.d.). Michigan Economic Development Corporation. <https://www.michiganbusiness.org/services/data-centerreitissuegulate/>

⁴⁶ *2025-11-13 letter to msf re data center tax exemption guidelines.* (n.d.). Retrieved from <https://www.documentcloud.org/documents/26285411-20.25-11-13-letter-to-msf-re-data-center-tax-exemption-guidelines/>

⁴⁷ Lyjijynen, N. (2025, December 11). *Comments on data center generation » mieibc.* MIEIBC. <https://www.mieibc.org/comments-on-data-center-generation/>

Table 1. Summary of Sales and Use Tax Exemptions for Qualified and Enterprise Data Centers

	Qualified Data Center	Enterprise Data Center
Key definitional feature	Must receive 75% or more of revenue from colocated businesses that are not affiliates of the owner/operator	Must have a minimum of \$250M equipment investment
Job Requirements	400-1,000 aggregate statewide	30 per facility at 150% median prosperity wage
Clean Energy	No requirements	90% of usage (interpretation unclear, see below)
Green Building Standards	No requirements	One or more certified standards within 3 years
Water Source	No requirements	Municipal
Property Tax	No requirements	Cannot receive sunset, state, or local property tax benefits without local approval
Certification Requirements/Details	To claim the exemption when purchasing eligible data center equipment, the purchaser must provide a completed Michigan Sales and Use Tax Certificate of Exemption (Form 3372) to its seller. Must also file Form 5726	Must receive Michigan Strategic Fund certification before making purchases that are qualified for the exemption. No new certifications after December 31, 2029.
Revocation	No requirements	If certification is revoked, repayment of all related tax exemptions is required (if the revocation occurs 10 years after certification, 50% of the tax exemptions must be repaid).

Local Taxes and Employment

Job creation is a primary focus of state-level tax incentives. While state-level estimates of Michigan-specific job creation suggest there will be significant employment opportunities,⁴⁸ it is unclear how many direct or indirect data center jobs could be filled by residents of the host community. The vast majority of direct data center jobs are temporary construction positions. Once completed, there would be on-site operational and security positions, but estimates of how many range from dozens⁴⁹ to hundreds.

The more significant economic incentive for the host community would likely be the property taxes paid by the data center developer and operator. Because data center equipment is costly, data centers can significantly increase the property tax base. However, these increases may shift year-to-year.

The State Tax Commission lists data centers as a commercial use,⁵⁰ and the equipment within the data center would be taxed as commercial personal property. Most of the equipment, including servers and networking equipment, would likely be reported in Section F of the Personal Property Statement, which has a relatively fast depreciation.⁵¹ The 2026 multipliers for Section F assess true cash value at 60% of the installed cost of that equipment in year 1, but just 8% of the true cash value when that equipment is 7 years old. As older equipment in the data center is replaced with newer equipment, that new equipment would again start out at a 60% multiplier, but—as is the case with many classes of personal property—there may be years when the taxable value of the personal property is less than the previous year. If there is a large increase in the real property on the site (for example, from new buildings or significant site improvements), these swings in tax revenue may be more muted. Regardless, local governments may need to think strategically about how to utilize these new personal property tax revenues. Lessons might be gleaned from our recent guide on renewable energy revenue streams.⁵²

⁴⁸ Group, T. B. (n.d.). *Michigan data center jobs 2026: Openai stargate hiring update*. Retrieved February 4, 2026, from <https://thebirmgroup.com/michigan-data-center-jobs-2026-stargate-project-brings-thousands-of-opportunities-to-washt-enaw-county/>; Gov. Whitmer submits public comment in support of stargate project, creating thousands of jobs, meeting strong environmental standards. (n.d.). Retrieved February 4, 2026, from <https://www.michigan.gov/whitmer/news/press-releases/2025/12/03/whitmer-submits-public-comment-in-support-of-stargate-project-creating-thousands-of-jobs>

⁴⁹ Chung, W. (2025, October 6). *Data center staffing levels: How many people does a facility need?* Broadstaff. <https://broadstaffglobal.com/data-center-staffing-levels-how-many-people-does-a-facility-need>

⁵⁰ Michigan State Tax Commission Property Classification MCL 211.34c. (2018) https://www.michigan.gov/treasury/-/media/Project/Websites/treasury/MISC_4/ClassificationRealProperty.pdf?rev=efb8cc4963494e1393d2675b4fab9092&hash=B7240AE93E5ABE808D0CDC7FD8AB38BE

⁵¹ 2026 Personal Property Statement (Form L-4175), https://www.michigan.gov/taxes/-/media/Project/Websites/taxes/Forms/Property-Tax/632/632_ty2026.pdf?rev=9bd5f68f4fda4d828cc4306ea6ba749b&hash=F72987A0B2EC0E2795E0C065E33E265D

⁵² Stoetzer, O., Krol, M., & Mills, S. (2025). *Strategies for Renewable Energy Revenue: A Guide for Michigan Local Governments*. University of Michigan Center for EmPowering Communities. <https://graham.umich.edu/project/renewable-energy-revenue>

Local governments do have discretion to offer data center property tax incentives, including via PA 198 agreements.⁵³ In certain situations, data centers may also be eligible for property tax exemptions via the Michigan Renaissance Zone Act, which are not approved at the local level but instead approved by the Michigan Strategic Fund.⁵⁴ In order to qualify for the “enterprise” data center sales and use tax exemption, however, any local property tax incentive must be approved by each local unit of government affected by the incentive. This is not a provision to qualify for the “qualified” data center sales and use tax exemption.

Impacts on Electricity Rates

Another common data center question is whether they will increase electricity costs, given the reports on electricity rate increases in some states like Virginia and Ohio that have undergone significant data center development.^{55, 56} There is also, however, nationwide data finding the opposite impact: that looking across all states, those that had increased electricity load typically saw decreases in electricity rates compared to the others.⁵⁷

There are multiple reasons that conflicting observations can be true at the same time. One key point is that it is challenging to assess what would have happened to electricity rates in the absence of data center load growth. Across the country, U.S. average retail electricity prices have been rising faster than inflation for residential consumers due to costs associated with grid maintenance and capacity expansion.⁵⁸ On the one hand, the load growth that data centers bring can help spread these fixed grid-related costs over more kilowatt-hours of electricity consumed, thereby reducing increases or the rates themselves for residential customers. On the other hand, if grid expansion is only needed to bring data center load online, data centers may be contributing to cost increases.

In Michigan, customer utility rates and ratemaking policy are set by the MPSC. By statute, Michigan abides by cost-of-service ratemaking, which means that utility rates assign “costs to customer classes based on usage patterns.”⁵⁹ Additionally, Michigan’s recent legislation on enterprise data center use and sales tax exemptions dictates that these data centers can only qualify if they use an electric service rate that prevents residential customers from subsidizing

⁵³ 1974 PA 198, MCL 207.551 to 207.572

⁵⁴ 1996 PA 376, MCL 125.2681 to 125.2696

⁵⁵As data centers for AI strain the power grid, bills rise for everyday customers. (n.d.). Washington Post. <https://www.washingtonpost.com/business/2024/11/01/ai-data-centers-electricity-bills-google-amazon/>

⁵⁶ Saul, J. Nicoletti, L. Pogkas, D. Bass, D. and Malik, N. (2025, September 29) AI data centers are sending power bills soaring. Bloomberg Technology. <https://www.bloomberg.com/graphics/2025-ai-data-centers-electricity-prices/>

⁵⁷ Wiser, R., O’Shaughnessy, E, Barbose, G., Cappers, P., & Gorman, W. (2025) Factors influencing recent trends in retail electricity prices in the United States. The Electricity Journal. <https://www.sciencedirect.com/science/article/pii/S1040619025000612#sec0020>

⁵⁸New Berkeley Lab report summarizes trends in retail electricity prices and price drivers. (2025, January 6). Energy Markets & Planning Berkeley Lab; Lawrence Berkeley National Laboratory.

<https://emp.lbl.gov/news/new-berkeley-lab-report-summarizes-trends-retail-electricity-prices-and-price-drivers>

⁵⁹Putnam, C. (n.d.). Cost of Service Ratemaking. Michigan Public Service Commission Department of Licensing and Regulatory Affairs. <https://pubs.naruc.org/pub.cfm?id=53889A44-2354-D714-5158-979D43EA47CF>

their facilities' electric costs.⁶⁰ Some of the Commission's recent decisions were designed to ensure that large-load customers, such as data centers, contribute significantly to the new and embedded costs associated with expanding Michigan's electric grid.

⁶⁰Enterprise Data Center Sales and Use Tax Exemption Guidelines. (2025).

Considerations for Local Government Policy-Making

The primary tool that local governments have to shape data center development is zoning. The Michigan Zoning Enabling Act (MZEA) sets out the minimum procedures that local governments must follow when making amendments.⁶¹ It, along with past state and federal court cases, also sets parameters for zoning authority. For example, the MZEA states that local zoning ordinances “shall not have the effect of totally prohibiting the establishment of a land use,” with only a few rare exceptions.⁶² While local governments have broad latitude to direct land uses to particular districts and set development standards or conditions on land uses, those standards and conditions must be reasonable and should be based on facts.⁶³

Furthermore, while there is much attention to the significant community benefits that a data center may be able to bring (e.g., financial contributions to park or open-space funds, fire departments, or other community priorities), there are limitations to making these agreements required as part of zoning approval, or enforcing them if the developer decides not to make-good on the agreement.⁶⁴ Agreements with developers for community benefits are more solidly enforceable if entered into in exchange for a public subsidy of the project, such as a local property tax abatement or some other publicly-funded improvement that will benefit the project.⁶⁵ As a result, we also briefly discuss property tax abatements below. Enforceable community benefits may also result from settling a lawsuit with the data center developer, but that path comes along with additional legal fees for the local government.⁶⁶

We offer the following considerations for local governments, but advise municipal officials to consult their local planner and municipal attorney before making any changes to their plans or zoning ordinances.

⁶¹ Michigan Zoning Enabling Act, MCL 125.3101 to 125.3702 (2006).

<https://www.legislature.mi.gov/documents/mcl/pdf/mcl-act-110-of-2006.pdf>

⁶² MCL § 125.3207

⁶³ MCL § 125.3504

⁶⁴ Review, T. R., & Elia, E. (2024, July 18). *Legislative exactions | the regulatory review*.

<https://www.theregreview.org/2024/07/18/elia-legislative-exactions/>

⁶⁵ Community Benefit Planning and Agreements: A Summary Overview. (2024). Michigan State University Center for Community and Economic Development.

https://ced.msu.edu/upload/community%20benefits/Community%20Benefits%20Brief_FinalVersion.pdf

⁶⁶ Consent Judgment, RD Michigan Property Owner I LLC v. Saline Township, No. 2025-001577-CZ (Washtenaw County Circuit Court Oct. 15, 2025).

<https://salinetownship.org/uploads/notices/SalineDataCenterConsentJudgmentFinalExecutionCopy492124804975v1.pdf>

#1: Consider whether your industrial zone is appropriate for data centers

The footprint of a data center and the state regulations that apply to this land use are not significantly different from those of other large industrial activities, so it may be logical for local governments to use their approach to industrial development as a starting point for data center policymaking. However, given limited greenfield industrial development in Michigan over the last three decades and the comparatively large footprint of data centers relative to other light industrial uses, we recognize that few Michigan communities have had robust conversations about their industrial zones. Now is the time for such a conversation.

The first step should be to review the spatial footprint of your industrial district(s) and the infrastructure capacity to serve them. Many industrial uses—not just data centers—require electricity infrastructure and access to water (even if only a well). Your community's master plan (sometimes called a comprehensive plan) may have already considered where infrastructure is most suitable for industrial development, and so you should compare the spatial extent of your current industrial zoning with what is suggested in the Master Plan. This will help you determine whether it is appropriate to expand your industrial district.

In addition to dictating where industrial uses may be permitted in your community, zoning also lays out which processes developers must follow if they wish to develop their properties. It is very common to allow industrial development “by-right” in industrial zones - that is, with limited discretion by the planning commission or Township board / City Council, so long as the developer meets all of the standards in the zoning ordinance (see Consideration #2). Given the increased scale of industrial developments, it may be appropriate to treat larger industrial uses (e.g., those greater than 15,000 square feet, or whatever has been typical in your community) as special land uses, which affords the Planning Commission and board the opportunity to give proposals additional review and apply conditions to their approval.

#2: Include quality-of-life impacts in industrial zoning regulation

Historically, industrial uses have been concentrated near other industrial uses to minimize impacts on surrounding land uses from emissions, noise, and light pollution. Industrial districts were commonly buffered from residential districts either through public infrastructure, such as roads or waterways, or through less sensitive uses, such as office or commercial zones. But in communities that have seen limited industrial activity, or in those where existing industrial zones are not large enough to accommodate new industrial activity like data centers, there may not be ample space to buffer from other land uses. As a result, a community might consider updating the standards in industrial zones to ensure that any new industrial activity—data centers included—is protecting quality-of-life in neighboring districts. Your community's most important quality-of-life

impacts to regulate may be informed by your comprehensive plan. Common considerations might include:

- Visual screening: While it is common to require vegetative screening in some districts, this requirement may not apply in industrial districts, particularly if your zoning ordinance did not anticipate that an industrial district would expand to abut residential areas.
- Sound: Some communities have community-wide sound standards that exist outside of zoning codes. These often apply to all noise emitters and may differentiate sound levels by time of day or day of the week (with a higher expectation of quiet on weekends). This approach sets a constant expectation for all land uses, not just industrial uses. If this is not practical, it is also possible to include sound standards for specific land uses or land-use classes. Standards that apply to large-scale renewable energy projects may be a useful starting point, as sound standards are common in the regulation of these facilities.⁶⁷
- Light: Another common concern about industrial activities, particularly in rural areas, is the light pollution they may cause, especially when they are developed in areas without streetlights. Some communities, including Emmet County,⁶⁸ have dark-sky ordinances that limit light pollution from all land uses. These same concepts can be applied specifically to industrial uses if that is the concern. Another option is to require dark-sky-compliant light fixtures for all proposed site plans.
- Decommissioning: Many industrial facilities have specialized designs with limited opportunities for reuse at the end of their life. From our brownfield experience, when a company is no longer in business or decommissioning the facility is too costly, these facilities are sometimes abandoned, creating an eyesore and public health hazard in the community and increasing redevelopment costs. As a result, it is increasingly common that industrial facilities enter into a decommissioning agreement that includes a financial guarantee that the facility, and any infrastructure that no longer has a useful purpose, will be removed at the end of its life. Again, it may be instructive to look to large-scale renewable energy projects for sample language.

These regulations would be in addition to the setbacks, height, lot-area coverage, and parking standards that are common in most zoning ordinances. While it is possible to use these more customary regulations to help buffer or minimize the impacts of industrial uses, there may be unintended consequences (e.g., industrial uses actually requiring more land to comply with large setback requirements) and so you may wish consider directly addressing the quality-of-life concern (e.g., sound, visual impact, light), rather than using setbacks as a proxy for those concerns.

⁶⁷ Krol, M., and Mills, S. (2024). Planning & Zoning for Battery Energy Storage Systems: A Guide for Michigan Local Governments. University of Michigan Center for EmPowering Communities. <https://graham.umich.edu/project/bess-guide>; Augst, T., Fierke-Gmazel, H., Gould, M. C., Krol, M., Mills, S., Neumann, B., Reilly, M., & Stoetzer, O. (2025). Planning and Zoning for Solar Energy Systems: A Guide for Michigan Local Governments (Updated ed.).

⁶⁸ Emmet County. (2023). *Emmet County zoning ordinance* (Ordinance No. 15-1, updated through April 28, 2023). https://www.emmetcounty.org/UserFiles/Servers/Server_3942756/File/Ordinances,%20Bylaws%20&%20Rules/Zoning%20Ordinance/Emmet-County-Zoning-Ordinance-4_28_2023.pdf

#3: Get commitments in writing

While it is ideal to use your zoning ordinance to set clear standards and thresholds that apply to data centers or industrial districts, you may be able to get some commitments or added specificity on particular impacts in writing. For example, if your community wants on-site generators to only run during power outages or for weekly testing, it may be beneficial to obtain that commitment in writing and specify permitted operating hours to minimize noise impacts on residents. If there are other commitments that matter to your community, such as delivery truck routes or transparency on water or energy usage, etc., consider getting them in writing as well.

The appropriate mechanism to secure written commitments for your community will depend on the specific agreement at hand and whether it is tied to zoning (for example, special land-use conditions or willingly offered terms by the developer as part of a conditional rezoning), a development agreement, or a discretionary property tax incentive. A municipal attorney can help identify the most appropriate mechanism, though guidance from the Michigan Municipal League is instructive for municipalities seeking community benefits commitments.⁶⁹

#4: Request a Property Tax Guarantee

A primary community-wide benefit of hosting a data center is the increase in the property tax base that accompanies the project. It is not uncommon, however, for the personal property tax tables to change over the life of an industrial project such as a data center, which can prompt disputes between the local government and the taxpayer over the property tax valuation. Having a written commitment that the developer will pay the property tax revenues they discuss during the permitting process may help reassure the community that these benefits will materialize.

This approach has proven successful in Dickinson County, which accepted a Property Tax Guarantee from the developers of the Groveland Mine Solar project.⁷⁰ In the guarantee, the developer committed to a floor for property tax payments to the local governments. If the tax tables change in a way that reduces their required payments, they will still pay the committed amount. If, however, the tax tables change in favor of the local government, the developer is still responsible for paying the higher taxes.

#5: Explore data center integration with other industrial infrastructure

While a data center developer likely views the heat generated by their facility as a waste stream, other industries see it as an input and invest in generating it. Thus, there may be local

⁶⁹ *Handbook for General Law Village Officials* (p. 71). (2024). Michigan Municipal League .
<https://mml.org/wp-content/uploads/2024/07/CH-14-Planning-and-Zoning.pdf>

⁷⁰ Stoetzer, O., Krol, M., & Mills, S. (2025). *Strategies for Renewable Energy Revenue: A Guide for Michigan Local Governments*.

opportunities for the data center to create a circular economy and put at least some of that heat to beneficial use. Opportunities include greenhouses, other industrial processes, and district heating systems, as is being proposed in Lansing.⁷¹ Your local government can encourage the use of this waste stream by proactively identifying existing land uses in your community that require heat and sharing those with potential data center developers.

Similarly, local governments can explore with the data center developer the possibility of co-locating data centers with electricity infrastructure, like solar or battery energy storage. While a data center is unlikely to be able to fully power itself with on-site energy generation due to a mismatch between the footprints of large-scale renewables and data center technologies, siting some infrastructure on-site at the data center can reduce the need to build power plants elsewhere. Furthermore, this electricity infrastructure might boost the local property tax base.

⁷¹Kaplan, L. V. (2025, November 5). *Proposed downtown data center focused on sustainability*. City Pulse. <https://www.lansingcitypulse.com/stories/proposed-downtown-data-center-focused-on-sustainability,164052>

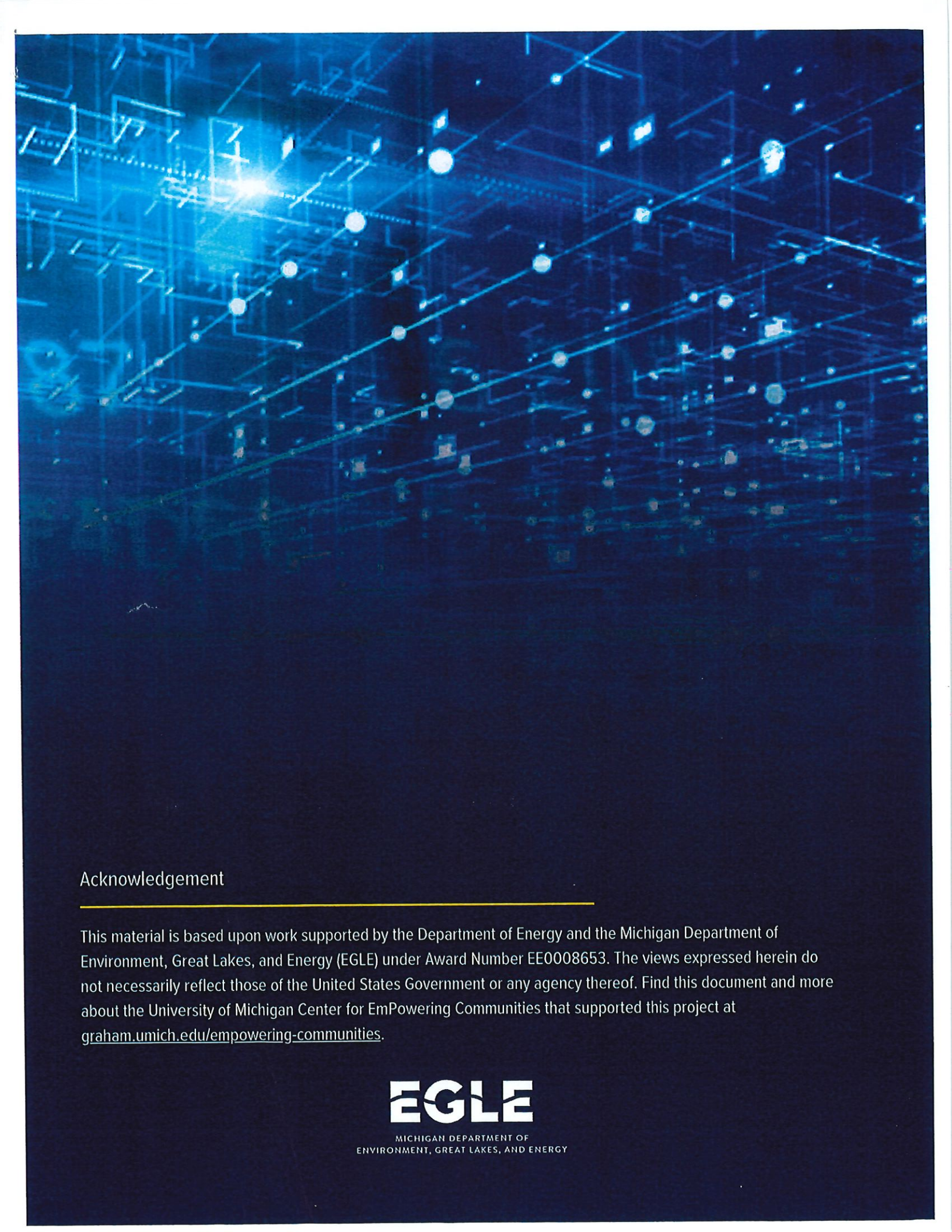
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THE UNIVERSITY OF
SYDNEY

The Digital Climate Footprint: From Global Data Centre Growth to Local Ecological Consequences

An Analysis of AI-Driven Warming and Its Impact on Australian Pollinators

Centre for AI, Trust and Governance

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30 September 2025

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Foreword – Professor Terry Flew

When the University of Sydney's Centre for AI, Trust, and Governance (CAITG) was first approached with the central premise of this report, I was sceptical. I was not certain that the exponential growth of artificial intelligence infrastructure could measurably threaten Australia's pollinator communities. How could fractional degrees of warming from data centres possibly matter to individual bee species? The answer, as this report demonstrates, lies in understanding the profound non-linearity of ecological systems and the amplifying effects of extreme weather events.

CAITG seeks to use interdisciplinary thinking to challenge conventional views. In this case, bringing different perspectives to the environmental implications of digital transformation. In this report, CAITG has developed what may be the first quantitative framework for translating global climate impacts into specific, measurable consequences for vulnerable species. The CAITG “bee barometer.”

The significance of this work extends far beyond its immediate findings about Australian pollinators. At a time when policymakers, technology leaders, and environmental scientists often operate in separate spheres, this interdisciplinary analysis provides a bridge between abstract climate projections and tangible ecological realities. The methodology developed, which links global energy consumption scenarios to local species vulnerability, offers a replicable model for understanding how technological choices cascade through natural systems.

The timing here is key. As artificial intelligence transforms industries and societies, we are simultaneously witnessing unprecedented rates of species decline and ecosystem disruption. The window for coordinated action is narrowing rapidly, and the decisions made in the next five years will determine whether we can successfully navigate the tension between technological progress and environmental stewardship.

This report demonstrates that understanding the full environmental cost of our digital infrastructure is essential for making informed choices about how we develop and deploy these powerful technologies. The “bee barometer” framework reveals that even seemingly negligible climate impacts can have material consequences for the natural systems that underpin our food security and ecological integrity. The report provides actionable insights for reducing these impacts through strategic interventions across technology, policy, and conservation domains.

The future of digital technology and ecological health need not be in conflict, but achieving this outcome will require the kind of integrated thinking and evidence-based analysis that this report exemplifies. I commend it to readers as a roadmap for more sustainable technological development.

Professor Terry Flew, FAHA

Australian Research Council Laureate Fellow, ICA Fellow
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Executive Summary

This report provides the first integrated analysis linking AI-driven data centre expansion to specific ecological impacts on Australian pollinator communities. As the digital economy undergoes unprecedented growth, the climate implications extend far beyond abstract temperature statistics to measurable risks for critical ecosystems and species.

Our analysis reveals that data centre growth between 2024 and 2035 could contribute 4.8 to 15.4 gigatonnes of cumulative CO₂ emissions, driving attributable global warming of 0.0026°C to 0.0084°C. While seemingly small, these figures become significant when translated through the “bee barometer” framework, demonstrating how fractional warming increases extreme heat events that push vulnerable species past critical thresholds. A 0.0046°C increase equates to 8% higher queen failure risk in honeybees.

Australia faces an acute “exporter’s paradox”: while domestic emissions represent 1% of the global total, fossil fuel exports contribute 4.5% of global CO₂ emissions, creating a feedback loop where export revenues fund an economy vulnerable to the climate impacts those exports create. Severe grid constraints compound this challenge, with data centre demand projected to grow from 5% to 15% of national electricity consumption by 2030, while transmission upgrades take up to a decade.

The economic stakes are substantial. Australia’s bee-dependent agriculture, valued at \$4.6 billion annually, faces material risks from climate-driven pollinator stress. Our species-specific analysis reveals distinct vulnerability pathways: reproductive failure in managed honeybees threatens agricultural stability, acute thermal mortality in native stingless bees risks social collapse, and climate-amplified fire regimes push specialist carpenter bees toward extinction.

Critical findings reveal that heat stress and Varroa mites create synergistic threats more severe than either alone. Heat-stressed honeybees parasitised by Varroa experience complete thermal tolerance loss and 46-67% increased metabolic demands, creating “multifactorial heat-induced death” cascades that could accelerate colony collapse beyond temperature-only predictions.

However, emerging economic incentives offer pathways for systemic change. Corporate grid independence investments are driven by business necessity—avoiding 4-8 year connection delays and capitalising on substantial tax incentives like 30% investment credits under the U.S. Inflation Reduction Act. These market-driven incentives align corporate self-interest with climate goals more effectively than sustainability messaging.

The report examines energy use in computing beyond data centres, including both operational and embodied energy in consumer devices across the US, UK, and Australia. This energy use outside data centres is comparable to data centre consumption:

Country	Annual Operational Energy (GWh)	Annualised Embodied Energy (GWh)
US	51,797	127,172
UK	9,805	28,132
Australia	4,597	10,886

The transformation toward sustainable digital infrastructure requires coordinated action across immediate, medium-term, and long-term timeframes. In the immediate term (first 12 months), operators should implement comprehensive energy audits, transition to hourly

carbon accounting, and establish renewable energy strategies. Corporate customers possess significant untapped market power to drive industry transformation through procurement decisions. When customers incorporate verified sustainability criteria with meaningful weighting (15-25% of evaluation) into vendor selection, they create incentives more powerful than voluntary corporate programs alone.

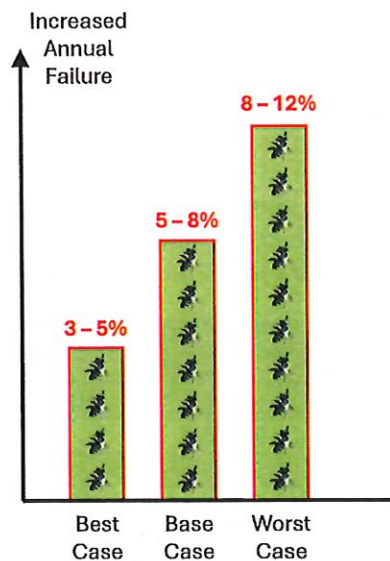
Medium-term initiatives (years one through three) focus on bringing renewable generation capacity online, deploying advanced cooling technologies, and establishing grid-interactive capabilities. Long-term transformation (years three through five and beyond) enables operators to achieve 80% or higher hourly carbon-free energy whilst demonstrating net-positive ecological impacts.

Our policy analysis proposes “conditional grid access” for new hyperscale data centres (>100 MW), requiring capped grid draw, private renewable generation, and flexible load capabilities. This transforms data centres from passive consumers to active grid participants, creating market incentives for 24/7 carbon-free energy innovation.

Comprehensive measurement systems encompassing energy metrics, operational efficiency, ecological impacts, and business value provide the foundation for transparent reporting. Understanding the Greenhouse Gas Protocol's Scope 1, 2, and 3 emissions framework enables both operators and customers to track their full environmental footprint and drive systematic improvement.

This analysis demonstrates that the race between technological growth and environmental stewardship requires immediate action. The 2024-2030 period drives near-term ecological tipping points, while Australia's unique position as both climate-vulnerable and fossil fuel exporter creates opportunities to pioneer integrated solutions serving as a global model for sustainable digital infrastructure.

The report analyses the effects on three bees common in Australia. However, apiculture means that the European Honeybee the best-known species. The vulnerability for European honeybees is reproductive health and the heat stressor for this bee species is sub-lethal heat stress on queens and drones (>38°C). The increase in annual rate of queen failure and reduced drone fertility is shown in the figure:



The effect of this can be expressed in terms of hives lost, if no adaptation occurs. There are about 870,000 hives in Australia (AgriFutures Australia, 2024). According to Gray et al. (2022), a 37-country average on “normal” queen failures is 4.5%. That is, 3,915 hives. Although the number of bees per hive varies by season, the queen failure will be highest in summer, when there are most bees in the hive. Conservatively assuming that the number of bees in a summer hive is 30,000, then the lost bees attributable to data centres is:

Percentage annual failure rate increase										
	Best case			Base case			Worst case			
	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%
Hives lost	117	157	196	235	274	313	352	392	431	470
Bees lost (million)	3.5	4.7	5.9	7.0	8.2	9.4	10.6	11.7	12.9	14.1

Part I: The Global Context - Quantifying the Climate Cost of Digital Growth

1. The AI-Fuelled Expansion - Projecting Data Centre Energy Demand to 2035

1.1 The New Paradigm: AI as an Unprecedented Energy Demand Driver

For much of the past decade, the narrative of data centre energy consumption was one of remarkable stability. Between 2010 and 2018, massive growth in demand for digital services was largely offset by concurrent improvements in server and data centre infrastructure efficiency, resulting in a relatively flat global energy footprint (Masanet et al., 2020). However, the recent and rapid proliferation of generative AI and other large-scale machine learning models has fundamentally broken this equilibrium. This new generation of computational tasks is orders of magnitude more energy-intensive, creating a paradigm shift in the sector's power requirements (International Energy Agency, 2024a; Masanet et al., 2020).

The scale of this shift is evident at both the micro and macro levels. A single query to an AI model like ChatGPT requires an estimated 2.9 watt-hours of electricity, nearly ten times the 0.3 watt-hours needed for a conventional Google search (International Energy Agency, 2024). This “AI Multiplier” effect at the level of a single computation scales up dramatically at the facility level. A traditional 5-megawatt (MW) data centre can see its energy demand increase tenfold to 50 MW when augmented with the specialised Graphics Processing Units (GPUs) required for AI workloads. The most ambitious new data centre campuses, designed explicitly for AI, are being planned at the gigawatt (GW) scale, with some early-stage projects envisioning 5 GW campuses—a power draw equivalent to that of five million homes (Deloitte, 2024).

This dynamic has led major research bodies to identify AI as the single “most important driver” of the current surge in data centre electricity demand (International Energy Agency, 2024). The International Energy Agency's (IEA) Electricity 2025 report projects that electricity demand from data centres worldwide is set to more than double by 2030 to around 945 terawatt-hours (TWh), with AI being the most significant driver of this increase. Similarly, BloombergNEF (BNEF) forecasts that US data centre power demand alone will more than double by 2035, rising from almost 35 GW in 2024 to 78 GW (BloombergNEF, 2024). This makes AI-driven hardware responsible for nearly half of the net increase in global data centre electricity consumption through 2030 (International Energy Agency, 2024). Recent projections indicate that the power demands of frontier AI training are accelerating even beyond current data centre growth estimates, with individual training runs potentially requiring 4-16 gigawatts by 2030—equivalent to powering millions of homes (Epoch AI & EPRI, 2025).

1.2 Scenario Analysis of Global Energy Consumption Forecasts

Given the rapid and uncertain nature of this expansion, a single-point forecast is insufficient. This report analyses a spectrum of scenarios from leading institutions to establish a credible range of potential energy futures through 2035. These scenarios are differentiated by their core assumptions regarding the pace of AI adoption, the rate of efficiency gains, and the impact of real-world infrastructure constraints.

Base Case Scenario: This scenario reflects a continuation of current policies and announced industry plans. It represents the most widely cited “business-as-usual” trajectory. Projections from the IEA and BNEF converge on a path where global data centre electricity consumption grows from approximately 415 TWh in 2024 to around 945 TWh by 2030, reaching between 1,300 TWh and 1,400 TWh by 2035. This corresponds to a compound annual growth rate of approximately 15%, a rate more than four times faster than the growth of total electricity consumption from all other sectors combined (International Energy Agency, 2024).

High-Growth Scenario: This scenario, reflected in the IEA’s “Lift-Off” case and Schneider Electric’s “Abundance Without Boundaries” case, models a future of accelerated AI adoption, enabled by a resilient global supply chain and fewer bottlenecks in grid expansion. Under these conditions, the IEA projects that global data centre electricity demand could exceed 1,700 TWh by 2035, a figure 45% higher than the Base Case (International Energy Agency, 2024). Schneider’s comparable scenario, driven by a techno-optimist belief that AI advances will solve any resource constraints, projects a similar trajectory, reaching 1,370 TWh by 2035.

Constrained-Growth Scenario: This scenario acknowledges the significant real-world impediments to unchecked growth. It models the impact of persistent grid connection delays, supply chain shortages for critical components, and a potentially slower-than-forecasted adoption of AI. A primary limiting factor is the availability of high-voltage power, with developers facing wait times of 4 to 8 years to secure new grid connections, compounded by global shortages of high-voltage transformers (International Energy Agency, 2024). A 2025 Deloitte survey of power and data centre executives found that 72% consider power and grid capacity to be the primary challenge for infrastructure development (Deloitte, 2024). Gartner’s forecast that power shortages will operationally constrain 40% of AI data centres by 2027 exemplifies this view (Gartner, 2023). The IEA’s “Headwinds” scenario captures this dynamic, projecting that energy demand plateaus at around 700 TWh after 2030 as physical limitations cap further expansion (International Energy Agency, 2024).

Efficiency-Driven Demand Surge (Jevons Paradox): This analysis introduces a fourth scenario to explicitly model the Jevons Paradox, a key concept in energy economics where technological efficiency improvements paradoxically increase total resource consumption rather than decreasing it. The paradox occurs because efficiency gains lower the effective cost of a service—in this case, computation—which stimulates greater demand, a phenomenon known as the “rebound effect”.

Empirical evidence strongly suggests this effect is present in the data centre sector. A 2024 thermodynamic analysis of data from Meta and Google found that despite achieving near-perfect Power Usage Effectiveness (PUE) ratios around 1.1, their total energy consumption continued to rise exponentially (Neupane et al., 2024). The study quantified direct rebound effects, showing that 10% efficiency improvements often lead to 15-25% increases in resource consumption (Neupane et al., 2024). This is further exemplified by the fact that major hyperscalers more than doubled their combined electricity use between 2017 and

2021 despite aggressive and successful efficiency programs (International Energy Agency, 2024).

The wide divergence in these forecasts is not an indication of flawed modelling but rather a clear map of the key variables. The ultimate energy footprint of the data centre sector is highly sensitive to policy decisions influencing grid build-out, corporate R&D strategies driving efficiency, and fundamental market and supply chain dynamics.

2. The Carbon Content of the Grid - Translating Power Consumption into Emissions

2.1 Global and Regional Grid Carbon Intensity: Current State and Trajectory

The quantity of CO₂ emitted per unit of electricity generated—the carbon intensity, typically measured in grams of CO₂ per kilowatt-hour (gCO₂/kWh)—is not a static or uniform value. It varies dramatically across different geographic regions and is projected to decline over time as renewable energy sources and other low-carbon technologies displace fossil fuels in the global electricity mix. According to the IEA, the global average carbon intensity of electricity generation was approximately 445 gCO₂/kWh in 2024. This figure is forecast to decline to 400 gCO₂/kWh by 2027, representing an average annual reduction of roughly 3.6% (International Energy Agency, 2024b).

However, this global average conceals vast regional disparities, creating a “geographic lottery” where the emissions impact of a new data centre is profoundly influenced by its location.

United States: The US grid is a patchwork of diverse regional systems. The national average carbon intensity in 2020 was approximately 387 gCO₂/kWh, yet state-level figures ranged from 894 gCO₂/kWh in coal-dependent Wyoming to just 4 gCO₂/kWh in Vermont. Driven by federal policies like the Inflation Reduction Act (IRA), the US power sector is on a path to significant decarbonisation, with projections showing a 42% to 83% reduction in emissions below 2023 levels by 2035.

European Union: The EU is on a rapid decarbonisation trajectory, with its average grid intensity falling by 20% in 2023 alone (European Environment Agency, 2024). Similar to the US, a wide gap exists between member states. Poland's grid remains carbon-intensive due to its reliance on coal, while the grids of Sweden, Finland, and France are among the world's cleanest (European Environment Agency, 2024). The EU's overarching policy framework aims for a nearly fully decarbonised power sector by 2035 (Ember, 2023; European Court of Auditors, 2024).

China: As the world's largest energy consumer, China's grid is an important factor. It remains heavily dependent on coal, which provided over 60% of its electricity in 2024, resulting in a high carbon intensity estimated between 599 and 614 gCO₂/kWh in recent years. Despite this, China is also the world's leader in renewable energy deployment. Studies suggest that an 80% carbon-free electricity system by 2035 is technically and economically feasible, a transition that would dramatically lower its national grid intensity (Energy Innovation, 2022).

2.2 Australia's Grid Paradox and Export Dependencies

The Exporter's Paradox – Fuelling Global Warming While Suffering Its Consequences

Australia's domestic energy challenges are compounded by its outsized role in the global climate problem. While domestic emissions account for around 1% of the global total, this figure obscures the nation's status as a fossil fuel superpower. By volume, Australia is the world's third-largest exporter of fossil fuels, but its high proportion of carbon-intensive coal makes it the second-largest exporter of fossil fuel CO₂ emissions, surpassed only by Russia (Climate Analytics, 2024). In total, emissions from Australia's fossil fuel exports are responsible for an estimated 4.5% of global fossil CO₂ emissions—a global carbon footprint three times larger than its domestic one (Climate Analytics, 2024).

This creates a direct and damaging feedback loop. The revenue from fossil fuel exports funds the national economy, yet the emissions from these same exports contribute directly to the global warming that amplifies the frequency and intensity of climate-related disasters—heatwaves, fires, and floods—within Australia. These events, in turn, increase the costs of infrastructure maintenance, disaster recovery, and agricultural losses, while straining the very grid upon which the nation's digital ambitions depend.

Grid Capacity Crisis – Digital Demand Meets Physical Limits

The exponential growth of data centres in Australia is placing unprecedented strain on a national electricity grid already navigating a complex transition away from coal-fired power. Forecasts indicate that data centres' share of national electricity consumption will rise from approximately 5% (1,050 MW) in 2024 to at least 8% by 2030, with high-growth scenarios projecting demand could reach as high as 15% (Atlas Economics, 2024). This demand is highly concentrated, with projects in Western Sydney alone expected to add over 2 GW of new load—a power draw equivalent to two large aluminium smelters.

While analysis suggests the grid can accommodate this growth until 2030, it is expected to become severely constrained in the following decade as the remaining coal-fired power plants are retired (Energy Council, 2024). The core challenge is a fundamental mismatch in timelines: the technology industry can deploy a new data centre in under two years, whereas planning and constructing major transmission upgrades can take up to a decade.

2.3 The Decarbonisation Race: Demand Growth vs. Grid Greening

The central tension that will determine the absolute emissions from the data centre sector is the race between the rate of its energy demand growth and the rate of grid decarbonisation. The outcome of this race will dictate when the sector's annual emissions peak and begin to decline. Currently, the race is imbalanced. In the IEA's Base Case, global data centre electricity demand is growing at approximately 15% per year (International Energy Agency, 2024). In contrast, the global average carbon intensity of electricity is declining at a much slower rate of roughly 3.6% per year (International Energy Agency, 2024b). This mismatch implies that, in the near-to-medium term, the explosive growth in consumption will overwhelm the incremental improvements in grid cleanliness. The result, as noted by the IEA, is a net increase in absolute annual CO₂ emissions from the sector (International Energy Agency, 2024).

3. The Cumulative Emissions Burden - A Multi-Scenario Quantification

3.1 Methodology for Cumulative Emissions Calculation

A multi-step methodology is employed for each of the energy consumption scenarios. First, the 2023 global data centre energy consumption of approximately 370 TWh is established as a baseline to isolate emissions resulting from growth (International Energy Agency, 2024). Second, for each scenario, a year-by-year energy consumption figure is established for 2024-2035, and the additional consumption for each year is calculated by subtracting the 2023 baseline. Third, a projected global weighted-average carbon intensity curve is applied for each year, declining annually from the 2024 baseline. Fourth, for each year (t), the additional emissions are calculated using the formula: $\text{Additional Emissions}_t (\text{MtCO}_2) = \text{Additional Energy Consumption}_t (\text{TWh}) \times \text{Carbon Intensity}_t (\text{gCO}_2/\text{kWh})$. Finally, the total cumulative emissions for the 2024-2035 period are the sum of the additional annual emissions.

3.2 Presentation of Results

The analysis reveals a significant range of potential outcomes, with cumulative emissions from data centre growth projected to be between 4.8 GtCO₂ in the Constrained-Growth scenario and a new high of 15.4 GtCO₂ in the Efficiency-Driven Demand Surge scenario. The Base Case results in cumulative emissions of 8.5 GtCO₂, while the High-Growth case yields 13.1 GtCO₂.

A critical pattern emerges from the annual data. Due to the race between rapid demand growth and slower grid decarbonisation, the annual emissions contribution is “front-loaded.” In all scenarios, the largest annual additions to the cumulative emissions burden occur in the near term (2024-2030). This dynamic underscores that actions taken in the next five years will have a disproportionately large impact on the total 12-year climate footprint of the sector. The introduction of the Jevons Paradox scenario reveals a strategic vulnerability: relying on technological efficiency as the primary mitigation strategy may be insufficient and could even be counterproductive without corresponding measures to manage or cap absolute consumption.

4. The Climatic Consequence - Contextualising the Attributable Warming

4.1 Application of the Climate Sensitivity Metric

The estimation of the temperature impact is based on the direct application of the relationship which links cumulative CO₂ emissions to global warming. The formula used is: $\text{Temperature Increase } (^\circ\text{C}) = \text{Cumulative CO}_2 \text{ Emissions (Gt)} / 1833 \text{ GtCO}_2 \text{ per } ^\circ\text{C}$. This relationship is a simplified representation of the Transient Climate Response to cumulative CO₂ Emissions (TCRE), a metric used by the Intergovernmental Panel on Climate Change (IPCC) to estimate near-term warming from a given quantity of CO₂ emissions. The value of 1833 GtCO₂ per 1°C of warming corresponds to a TCRE of approximately 0.55°C per 1,000 GtCO₂, which falls squarely within the scientifically accepted range (IPCC, 2021).

4.2 Contextualising the Warming: The Remaining Carbon Budget

Applying the climate sensitivity metric yields an attributable warming range of 0.0026°C to 0.0084°C. While these figures appear numerically small, their significance is revealed when viewed through the lens of the remaining global carbon budget—the total amount of CO₂ humanity can emit while retaining a chance to limit global warming to 1.5°C.

The IPCC's Sixth Assessment Report estimated the remaining budget for a 50% chance of staying below 1.5°C was approximately 500 GtCO₂ from the start of 2020 (IPCC, 2021). The cumulative emissions range from data centre growth (4.8 GtCO₂ to 15.4 GtCO₂) would consume 0.96% to 3.08% of this budget. This is a profoundly significant finding, representing the impact of a single sub-sector's growth over just one decade.

The central finding of this global analysis is that the growth in global data centre energy consumption between 2024 and 2035 is projected to contribute between 4.8 GtCO₂ and 13.1 GtCO₂ in cumulative emissions. More critically, when framed against recent, more stringent budget estimates as low as 80-130 GtCO₂, this single sub-sector's growth could consume between 3.7% and 16.4% of the world's remaining climate capacity. Applying a standard climate sensitivity metric of approximately 1°C of warming per 1833 Gigatonnes (Gt) of cumulative CO₂ emissions, this emissions range corresponds to an estimated incremental global average temperature increase of 0.0026°C to 0.0071°C (IPCC, 2021).

These scenarios—0.0026°C (Constrained-Growth), 0.0046°C (Base Case), and 0.0071°C (High-Growth)—form the quantitative foundation for understanding the ecological consequences that follow. They represent not abstract statistics, but measurable contributions to a global system already under stress.

Part II: The Ecological Translation - From Global Averages to Local Extremes

5. Introduction to the Bee Barometer Framework

5.1 From Global Averages to Local Extremes

The preceding quantitative analysis established three plausible, data-driven scenarios for incremental increases in global average temperature, directly linked to the expansion of digital infrastructure supercharged by Artificial Intelligence. These scenarios, which form the quantitative foundation for the ecological impact assessment that follows, represent more than abstract climate statistics—they are the input variables for understanding tangible ecological consequences.

While these figures represent a small fraction of a degree, their significance lies not in their absolute value but in their contribution to an already warming system. The relationship between a change in mean global temperature and the frequency of local extreme weather events is profoundly non-linear (Perkins-Kirkpatrick & Lewis, 2020). A minor shift in the average of a climatic distribution curve results in a disproportionately large increase in the probability of events occurring at the high-temperature tail of that distribution. This phenomenon can be understood as “loading the climate dice,” where the likelihood of rolling an extreme outcome increases with each increment of background warming.

This principle is not theoretical. It is an observed reality in Australia's recent climate history. Since national records began in 1910, Australia has warmed by an average of $1.51 \pm 0.23^\circ\text{C}$, with most of this warming occurring since 1950 (Bureau of Meteorology, 2024). This seemingly modest increase in the mean has driven a dramatic amplification of extreme heat. According to the Bureau of Meteorology and CSIRO (2024), very high monthly maximum temperatures that occurred less than 2% of the time between 1960 and 1989 are now occurring 11% of the time in the 2009–2023 period—an increase of approximately sixfold. The number of days in 2019 when the national average maximum temperature exceeded 39°C was greater than the cumulative total for the preceding 59 years combined (Bureau of Meteorology, 2024).

Therefore, the fractional degree increases attributable to data centre growth are not isolated, negligible quantities. They represent an additional forcing on an already stressed and amplified system. The true ecological signal of this AI-driven warming is not the change in the global average itself, but its measurable contribution to the increased frequency and intensity of localised, short-duration, high-intensity heat events. These are the very events that push biological systems, such as bees, past their physiological and ecological tipping points.

5.2 Australia's Exceptional Climate Vulnerability

Australia's Unique Vulnerability to Background Warming

Australia exhibits exceptional vulnerability to incremental warming due to its continental geography and climate patterns. The country has already warmed by 1.51°C since 1910—exceeding the global average—with the most rapid warming occurring since 1990 (Bureau of Meteorology, 2024). This background warming creates three unique vulnerability characteristics:

- Extreme heat amplification as Australia’s flat continental interior lacks moderating oceanic influences found in archipelagic nations. Since 1960, days above 35°C have increased by 15-20% across most regions, with some areas experiencing 40+ additional extreme heat days annually (CSIRO, 2024). The 2019-20 Black Summer fires burned 18.6 million hectares—an area larger than England and Wales combined—demonstrating how incremental warming translates into catastrophic ecological events.
- Fire regime disruption. Unlike temperate regions such as Canada or northern Europe where fire seasons are discrete, Australia experiences year-round fire risk across its continent. Climate change has extended fire seasons by 75 days since the 1970s, with some regions now experiencing fire weather on 350+ days annually (Dowdy et al., 2019). This creates persistent stress on fire-adapted ecosystems that evolved under more predictable burning cycles.
- The isolation of pollinators. Australia’s island biogeography means pollinator populations cannot migrate to climate refugia as readily as continental species. Unlike European bees that can potentially shift ranges northward across connected landmasses, Australian species face oceanic barriers that prevent escape from warming conditions.

A Tale of Three Fire Regimes: Australia, California, and Canada

While other regions like California and Canada are also global wildfire hotspots, their climate-fire dynamics differ, highlighting the unique nature of the Australian threat. Australia’s vulnerability is defined by ecological scale—a single fire event can impact an area the size of a small country, generating continental-scale smoke plumes and catastrophic biodiversity loss.

Table 1: Three fire regimes

Attribute	Australia	California	Canada
Primary Ecosystem	Eucalypt forests, grasslands, heathlands	Chaparral, mixed conifer forests	Boreal forests
Dominant Ignition Source	Lightning and human activity	Primarily human-caused (84%)	Primarily lightning-caused (55%)
Key Climatic Driver	Prolonged drought, extreme heat, strong winds	Santa Ana winds, seasonal drought, high temperatures	Rapid northern latitude warming, drought
Fire Characteristics	Extremely large, fast-moving, continent-scale events	High-intensity fires in densely populated wildland-urban interface	Massive, remote fires with long burn durations
Primary Challenge	Vast scale of fires, ecological devastation	High risk to life and property in urban interface	Remote access, carbon release from permafrost
Community Response	“Leave early” or “Stay and defend” policies	Mandatory mass evacuations	Evacuation of remote and Indigenous communities

5.3 Methodological Framework for Temperature-Extreme Projections

To operationalise the translation from global warming increments to local extreme frequency changes, this analysis employs a non-linear scaling approach based on observed Australian climate data. Recent research demonstrates that when global warming increases from 1.5°C to 2.0°C, Australian heatwaves become 85% more frequent and may last up to a month under 3.0°C warming scenarios (Hirsch & King, 2020). Under 2°C global warming, Australian cities could experience unprecedented temperatures of 50°C—temperatures that exceed existing records by 3.8°C in New South Wales and 2.3°C in Victoria (Lewis & King, 2017).

The projection methodology utilises the observed relationship where Australia's 1.51°C mean warming has amplified the frequency of certain temperature extremes by approximately 500% (a sixfold increase) (CSIRO, 2024). This yields an empirically-derived amplification factor of approximately 3.31 additional extreme days per degree of mean warming. However, this relationship is non-linear and varies by region, threshold temperature, and seasonal patterns.

Table 2: Projected Increase in Extreme Heat Day Frequency in Key Australian Bee Habitats Under Three Warming Scenarios

Region	Critical Temperature Threshold (°C)	Baseline Frequency (Current Days/Year)	Projected Additional Days/Year (Constrained-Growth: +0.0026°C)	Projected Additional Days/Year (Base Case: +0.0046°C)	Projected Additional Days/Year (High-Growth: +0.0071°C)
Coastal NSW / SE QLD (<i>A. mellifera</i> , <i>T. carbonaria</i> , <i>L. aeratus</i>)	38	8.5	+0.028 (±0.014)	+0.050 (±0.025)	+0.077 (±0.039)
	42	1.2	+0.004 (±0.002)	+0.007 (±0.004)	+0.011 (±0.006)
	45	0.3	+0.001 (±0.001)	+0.002 (±0.001)	+0.003 (±0.002)
Kangaroo Island, SA (<i>A. mellifera</i> , <i>L. aeratus</i>)	38	4.1	+0.014 (±0.007)	+0.024 (±0.012)	+0.037 (±0.019)
	42	0.5	+0.002 (±0.001)	+0.003 (±0.002)	+0.005 (±0.003)
	45	0.1	<0.001	<0.001	0.001 (±0.001)

Note: Baseline frequencies are derived from Australian Bureau of Meteorology climate data for representative locations (Sydney and Adelaide airports, 1991-2020 averages). Projected additional days are calculated using the empirically-derived amplification factor of 3.31 per degree of warming, with uncertainty ranges (±50%) reflecting regional and seasonal variability.

This table represents the critical bridge between the global climate analysis and the ecological consequences that follow. It translates abstract global warming scenarios into biologically relevant changes in the frequency of extreme heat events within the core habitats of Australia's key pollinator species.

6. The Generalist Under Pressure - *Apis mellifera* (European Honeybee)

The European honeybee (*Apis mellifera*) serves as the foundation case study for understanding how incremental warming translates into economic and agricultural risk. As Australia's primary agricultural pollinator and the cornerstone of a multi-billion dollar industry valued at AUD \$4.6 billion annually (Gordon & Davis, 2023), its widespread distribution and sophisticated social thermoregulation grant it a degree of resilience not afforded to many native species. However, this resilience has limits, and the projected warming scenarios reveal vulnerability pathways that extend from direct thermal stress to more insidious sub-lethal impacts on reproductive capacity.

6.1 Direct Thermal Stress and the Limits of Colony Defence

A honeybee colony functions as a superorganism, employing collective behaviours like fanning, bearding, and evaporative cooling (water collection) to maintain the core brood area within a remarkably stable temperature range, typically 33–36°C (Stabentheiner et al., 2010). However, extreme external heat can overwhelm these defences, pushing internal hive temperatures past critical physiological thresholds.

The most vulnerable life stage is the brood (eggs, larvae, and pupae). Brood survival drops to zero when hive temperatures reach and are sustained at 38°C (Khan et al., 2024). Referring to the projections in Table 1, the incremental warming from data centre growth contributes to an increased frequency of days where ambient temperatures reach this critical level. Under the Base Case scenario (+0.0046°C), coastal NSW and SE Queensland—major honeybee production regions—are projected to experience an additional 0.050 days per year exceeding 38°C, with the High-Growth scenario contributing an additional 0.077 days annually.

While these increments may appear small, they represent measurable increases in the risk of catastrophic brood mortality during prolonged heatwaves. During such events, particularly in unshaded apiaries, the colony's ability to dissipate heat becomes saturated. The internal hive temperature can rise to match and even exceed the external temperature, leading to catastrophic brood mortality. While the loss of a single day's worth of eggs may be recoverable, a multi-day heatwave—an event made more likely by background warming—can destroy a significant portion of the colony's developing workforce, weakening it for weeks to come.

Recent experimental studies demonstrate that honeybee colonies show measurable stress responses during simulated heat waves, with 70% increased foraging activity and doubled water collection, but these adaptations exhaust colony reserves and reduce buffering capacity against additional stressors (Bordier et al., 2017). Adult worker bees are more heat-tolerant than the brood, able to survive brief exposures to temperatures around 50°C. However, their lethal limit for sustained exposure is significantly lower; laboratory studies show they typically die within 24 hours at a constant temperature of 45°C (Khan et al., 2024). The high-growth warming scenario contributes to an increased probability of ambient

temperatures reaching this lethal threshold, with coastal regions experiencing an additional 0.003 days per year where temperatures exceed 45°C.

6.2 The Hidden Killer: Sub-Lethal Impacts on Reproduction

While direct mortality from heat is a visible and acute threat, a far more pervasive and systemic risk lies in the sub-lethal impacts of heat stress on the reproductive health of queens and drones. These impacts are not immediately obvious but can lead to a gradual decline and eventual collapse of the colony, a phenomenon known as “queen failure” (McAfee et al., 2019). This represents the most significant long-term threat to the viability of Australia’s managed honeybee population.

The reproductive integrity of a colony is uniquely fragile. A queen mates only during a brief nuptial period at the beginning of her life, storing a lifetime supply of sperm in her spermatheca. The viability of this stored sperm is the single most critical factor in the long-term health and productivity of the colony. Research has demonstrated that this stored sperm is highly vulnerable to heat. Exposing a queen to temperatures above 38°C for more than two hours can cause irreversible damage and significant loss of sperm viability (McAfee et al., 2019). More extreme laboratory studies, simulating conditions that could be experienced during transport or in a heat-stressed hive, found that a four-hour exposure to 42°C reduced stored sperm viability by a staggering 56% (McAfee et al., 2019).

The increased frequency of days exceeding these critical thresholds under all three warming scenarios creates a measurable increase in the risk of queen reproductive failure. Under the Base Case scenario, the additional 0.007 days per year exceeding 42°C in coastal regions may appear minimal, but when compounded across thousands of queens and multiple years, it represents a systematic increase in the risk of fertility damage across the managed honeybee population.

Drones (male bees) are even more susceptible to heat stress. Their primary biological function is to mate with virgin queens, and their fertility is paramount. Studies show that exposing drones to 42°C for just four hours results in high mortality and can reduce the viability of sperm in surviving males by up to 75% (McAfee et al., 2025). The increased frequency of heatwave conditions projected under the warming scenarios will therefore reduce both the quantity and quality of drones available in the landscape, diminishing the mating prospects for new queens.

The consequence of these reproductive injuries is a slow, cascading failure. A queen with damaged sperm can no longer lay a sufficient number of fertilised eggs, which develop into female workers. Her brood pattern becomes patchy, the colony’s workforce dwindles, and it can no longer perform essential tasks like foraging, defence, and thermoregulation, leading to its eventual demise (McAfee et al., 2019). This is not a hypothetical risk. Analysis of queens that have failed in commercial apiaries found that approximately 45% exhibited protein expression signatures consistent with having experienced significant heat-shock, providing a direct molecular link between the laboratory findings and real-world colony losses (McAfee et al., 2019).

6.3 Synergistic Threats: Heat Stress and Disease Susceptibility

Heat stress significantly increases pollinator susceptibility to diseases and parasites, creating a “synergistic mortality pathway” more severe than individual stressors alone. Research demonstrates that heat-stressed honeybee colonies show 40-60% reduced immune function, making them vulnerable to opportunistic pathogens (Alaux et al., 2010).

The Varroa-Heat Stress Synergy

The parasitic mite *Varroa destructor* represents the most critical case study of synergistic threats. This mite is the most significant pest in beekeeping worldwide, weakening bees by feeding on their fat body tissue—an organ crucial for immunity, energy regulation, and detoxification—and acting as a primary vector for debilitating viruses like Deformed Wing Virus (González-Gómez et al., 2021).

Research reveals a devastating synergy between heat stress and Varroa parasitism. Parasitism by Varroa causes a “substantial drop” in the thermal tolerance of honeybees, an effect so pronounced that it can completely negate any adaptive benefits of being acclimated to warmer temperatures (González-Gómez et al., 2021). This interaction creates a physiological crisis: heat stress forces bees to expend more energy on thermoregulation, while Varroa parasitism simultaneously increases an individual bee’s metabolic rate by 46-67% (González-Gómez et al., 2021).

This combined energy drain, occurring in an organism whose energy stores are already being depleted by the mite, severely compromises survival. Furthermore, while heat shock can induce an antiviral immune response in healthy bees, Varroa parasitism is known to suppress the bee’s immune system, making it more susceptible to the very viruses the mite transmits (Yang & Cox-Foster, 2007). This complex interplay suggests a “multifactorial heat-induced death” cascade, where rising temperatures prime entire honeybee populations for collapse.

6.4 Economic Implications and Industry Resilience

The projected impacts on honeybee reproduction carry substantial economic implications for Australia’s agricultural sector. The \$4.6 billion annual value of honeybee pollination services represents 65% of Australian agricultural production across 35 industries (Gordon & Davis, 2023). Even a modest 10-15% decline in queen fertility—a plausible outcome under the Base Case warming scenario—could reduce pollination efficiency and crop yields, with cascading effects through food supply chains.

Historical precedents demonstrate the vulnerability of intensive agricultural systems to pollinator stress. The 2022 Varroa mite detection represented a major biosecurity threat with estimated annual costs of \$16.4-38.8 million just to prevent establishment (Plant Health Australia, 2022). Climate-induced reproductive stress represents a more insidious but potentially more pervasive threat, as it affects the fundamental breeding capacity of managed honeybee populations rather than simply requiring additional management inputs.

7. The Heat-Sensitive Native - *Tetragonula carbonaria* (Carbonaria Stingless Bee)

In contrast to the adaptable European honeybee, the native *Carbonaria* stingless bee (*Tetragonula carbonaria*) presents a clear case study of a species with sharply defined and lower thermal tolerances. This highly social, eusocial bee is common along Australia’s eastern seaboard, from tropical North Queensland to temperate southern New South Wales (Shanks, 2015). Its vulnerability to the projected warming scenarios is not defined by subtle reproductive declines, but by the acute risk of catastrophic mortality when ambient temperatures breach a well-documented physiological ceiling, leading to a unique form of social collapse.

7.1 Breaching the Thermal Ceiling: Projecting Forager Mortality

The thermal physiology of *T. carbonaria* dictates a narrow operational window. Foraging activity ceases at temperatures below 18°C, confining its activity to the warmer parts of the day (Shanks, 2015). At the upper end of the spectrum, its tolerance is extremely limited. The critical thermal maximum (CT_{max}), the temperature at which an organism loses coordinated movement, for *T. carbonaria* foragers is approximately 43.1°C (Vandera et al., 2023). More critically, the lethal temperature is even lower. Controlled experiments have demonstrated that exposure to an ambient temperature of 42°C for just one hour results in 95% mortality among foragers (Vandera et al., 2023).

This specific, well-defined lethal threshold allows for a direct comparison with the projected increase in extreme heat events. As detailed in Table 1, each of the three warming scenarios contributes to an increased probability of days exceeding 42°C within the species' core habitat in coastal NSW and SE Queensland. Under the Base Case scenario, the frequency of these “mass mortality events” increases by 0.007 days per year, while the High-Growth scenario contributes an additional 0.011 days annually. During such an event, a significant portion of the colony's foraging workforce, the individuals most exposed to external ambient temperatures, would be expected to perish. This represents a direct and quantifiable link between the incremental warming from data centre growth and the loss of a vital native pollinator.

Recent research confirms that Australian stingless bees show particular vulnerability to heat stress, with behavioral switching occurring at 34°C and complete loss of flight capacity below 18°C, constraining them to increasingly narrow temperature windows as climate extremes intensify (Vandera et al., 2023). The species shows minimal acclimation capacity, with laboratory studies indicating no significant improvement in heat tolerance following acute exposure, suggesting that rapid adaptation to warming climates is unlikely.

7.2 The “Zombie Colony”: A Resilient Brood but Decimated Workforce

A critical and fascinating nuance in the thermal biology of *T. carbonaria* is the differential heat tolerance between life stages. While adult foragers are acutely sensitive to heat, research has surprisingly shown that the brood—the larvae and pupae developing within the insulated core of the nest—is significantly more resistant to heat exposure (Shanks, 2015). This disparity in vulnerability creates a pathway to a novel form of colony collapse.

A colony may physically survive a heatwave that kills off 95% of its foraging population. The queen, who remains deep within the nest, and the heat-resistant brood may be unharmed. However, the colony as a functioning social unit would be crippled. The loss of the adult workforce severs the colony's connection to the outside world, halting the inflow of essential pollen and nectar. There would be insufficient workers to tend to the developing brood, defend the nest against predators like phorid flies or small hive beetles, or maintain the nest structure (Shanks, 2015).

This leads to the emergence of a “zombie colony”: an entity that is technically alive, with a queen and developing young, but is ecologically dead. It is functionally inert, unable to sustain itself or reproduce, and destined for a slow collapse through starvation, predation, or disease. This mechanism of failure, driven by the selective removal of a single, heat-sensitive caste, highlights how climate change can dismantle the intricate social structure that is the very basis of a eusocial insect's success.

7.3 A Climate-Driven Migration: Projecting Range Shifts

The distribution of *T. carbonaria* is fundamentally constrained by climate. Its southern limit is dictated by the need for ambient temperatures to exceed 18°C for foraging flight, while its persistence in hotter northern regions is challenged by its low tolerance for extreme heat (Shanks, 2015). As average temperatures rise, the species' suitable climatic envelope is expected to shift.

Based on occurrence data from the Atlas of Living Australia, which confirms its concentration along the eastern coast, a warming climate is projected to facilitate a southward expansion of its potential range. However, this forced migration is fraught with challenges. The bee's ability to successfully establish in new territories depends not only on a suitable climate but also on the availability of essential resources, primarily hollow trees for nesting and a consistent supply of floral resources (Shanks, 2015).

Furthermore, this southward shift brings *T. carbonaria* into increasing contact and competition with its closely related congener, *Tetragonula hockingsi*. *T. hockingsi*, a more tropically adapted species, has also been observed expanding its range southwards, a trend potentially accelerated by both climate change and the human-assisted movement of managed hives (Chapman et al., 2018). This increased range overlap could lead to heightened competition for nesting sites and floral resources, and potentially increase the frequency of interspecific nest usurpations, where one colony takes over the nest of another. The warming scenarios, therefore, do not simply threaten existing populations with heat stress but also act as a catalyst for complex, unpredictable ecological reorganisations.

8. The Specialist on the Brink - *Lestis aeratus* (Green Carpenter Bee)

The Green Carpenter Bee (*Lestis aeratus*, also known as *Xylocopa aerata*) provides a compelling and urgent example of climate change acting as a "threat multiplier." This large, iconic, and visually stunning native bee is not primarily threatened by direct thermal stress, but by the way in which warming exacerbates existing pressures and disrupts the delicate ecological relationships upon which its survival depends. As a highly specialised and already endangered species with a fragmented distribution, its fate under the projected warming scenarios illustrates the profound vulnerability of specialists in a rapidly changing world.

8.1 An Indirect Threat Multiplier: Climate Change and Fire Regimes

The core vulnerability of the Green Carpenter Bee is its highly specialised nesting requirement. It is a solitary bee that excavates its nest tunnels exclusively in dead, soft, pithy wood (Glatz et al., 2015). In its remaining habitats on Kangaroo Island and in disjunct populations around Sydney and the Great Dividing Range in NSW, this substrate is provided almost entirely by two specific plant types: the dead flower spikes of *Xanthorrhoea* grass trees and the dead trunks and branches of mature *Banksia* shrubs (Santos et al., 2020). The availability of these two resources is intrinsically linked to the fire regime of the landscape, but on critically different timescales. *Xanthorrhoea* flower spikes provide a short-term, ephemeral nesting resource, becoming suitable for the bees approximately 3 to 6 years after a fire has passed through an area (Santos et al., 2020). In contrast, *Banksia* provides a long-term, stable nesting refuge. However, *Banksia* plants must mature, die of old age, and begin to decay before they become suitable, a process that requires at least 30 years without fire (Santos et al., 2020). A healthy ecosystem for the Green Carpenter Bee depends on a

mosaic of fire histories that provides a continuous supply of both these short-term and long-term resources.

Climate change is fundamentally disrupting this temporal balance. The observed and projected warming is leading to an increase in extreme fire weather and a lengthening of the fire season across large parts of southern Australia, the bee's core habitat (CSIRO, 2024). Attribution studies confirm that fire risk has increased 30% since 1900 due to anthropogenic climate change, with megafire frequency (>1 million hectares burned) markedly increasing since 2000 (Van Oldenborgh et al., 2020). This shift towards more frequent and intense fires creates a devastating "temporal trap" for the bee. The increased fire frequency prevents the establishment of the vital long-term *Banksia* refuges, as the landscape is re-burnt long before the 30-year fire-free interval can be reached. This forces the entire bee population to become dependent on the ephemeral, post-fire *Xanthorrhoea* resource. This reliance is precarious; if an area re-burns before the 3-6 year window of suitability, or if there are no fires in a region to trigger *Xanthorrhoea* regeneration, the nesting substrate disappears entirely. This climate-driven "ecological desynchronisation"—the breaking of the temporal link between the fire regime and the bee's life-cycle needs—is effectively engineering the species' habitat out of existence.

8.2 Recent Fire Impacts and Conservation Responses

The 2019-2020 Black Summer bushfires provided a devastating case study of this threat. Nearly 80% of known NSW habitat for *L. aeratus* was destroyed, and all Kangaroo Island conservation areas with artificial nesting sites burned (Youngsteadt et al., 2021). The fires affected 553 bee species (approximately one-third of Australia's known species), resulting in 9 species classified as Vulnerable and 2 as Endangered under conservation assessments (Batley et al., 2021).

However, innovative conservation interventions have demonstrated remarkable success. World-first post-fire recovery trials using artificial bee hotels achieved 100% occupancy across all sites, with 832 cavities occupied and an estimated 3,300+ native bees emerging in the next generation (Wilson & Smith, 2024). These interventions significantly enhanced native bee foraging activity compared to control sites, demonstrating practical pathways for post-fire recovery support. The success of artificial habitat provision suggests that targeted management can partially offset climate-driven habitat losses, though this requires ongoing investment and maintenance.

8.3 Habitat Contraction and the Search for Refuge

The Green Carpenter Bee is already extinct on mainland South Australia and in Victoria, with its remaining populations confined to Kangaroo Island and isolated pockets of heathland in NSW (When Bee Foundation, 2020). This fragmented distribution makes it extremely vulnerable to further pressures.

Species distribution models have been developed to project the bee's climatically suitable range under future warming scenarios. These models indicate that annual mean temperature is the strongest predictor of the species' distribution (Santos et al., 2020). Under all future warming scenarios, the suitable climatic envelope for both the bee and its key *Banksia* and *Xanthorrhoea* host plants is projected to contract towards the southeast of mainland Australia (Santos et al., 2020). This creates a dual pressure: the bee's physical nesting habitat is being destroyed by altered fire regimes, while its broader climatically suitable zone is simultaneously shrinking and shifting. The populations are being squeezed from two

directions, caught between the loss of their essential physical resources and the deterioration of the broader climatic conditions they require.

8.4 The Solitary Bee's Burden: Direct and Sub-lethal Heat Stress

As a solitary bee, *L. aeratus* lacks the social thermoregulatory buffers available to honeybees and stingless bees. Each individual female and her developing brood are directly exposed to ambient temperature fluctuations within their nest tunnel. While specific critical thermal maximum data for *L. aeratus* is not readily available, research on other large solitary bees, including other carpenter bees (*Xylocopa*), provides a strong basis for inferring likely impacts (Hamblin et al., 2017).

Research on solitary mason bees (*Osmia*) has demonstrated significant sub-lethal impacts of heat on male reproduction. In one study, a short-term, four-hour exposure to a sub-lethal temperature of 38°C was found to significantly reduce both the quantity and quality (viability) of sperm in male bees, even after a recovery period (Mokkapati et al., 2025). The increased frequency of days exceeding this threshold, as projected in Table 1, suggests that the reproductive fitness of male Green Carpenter Bees is likely to be compromised. Under the Base Case scenario, Kangaroo Island—a critical stronghold for the species—is projected to experience an additional 0.024 days per year exceeding 38°C. This direct physiological stress adds yet another layer of pressure, reducing the reproductive output and resilience of populations that are already critically threatened by the climate-driven collapse of their nesting habitat.

9. Synthesis and Implications - The Converging Pressures on Australia's Pollinators

The analysis of these three representative bee species reveals that the incremental warming attributable to the growth of AI-driven data centres contributes to a diverse and complex array of ecological risks. The “bee barometer” does not point to a single, uniform outcome, but rather illustrates three distinct pathways to vulnerability, demonstrating how a common climatic pressure can manifest in profoundly different ways depending on a species' biology, social structure, and degree of ecological specialisation.

9.1 Convergent Threats and Divergent Vulnerabilities

The three narratives converge to paint a picture of escalating pressure on Australia's vital pollinator communities:

For *Apis mellifera*, the resilient generalist, the primary threat is a slow, cryptic erosion of reproductive health. The danger is not immediate colony death but a systemic increase in “queen failure” driven by heat-induced damage to the fertility of both queens and drones. This poses a long-term, strategic risk to the stability of managed pollination services essential for Australian agriculture, potentially affecting the \$4.6 billion annual value of honeybee-dependent agricultural production.

For *Tetragonula carbonaria*, the heat-sensitive native, the threat is acute and direct. Its low thermal tolerance creates a clear tipping point where increasingly frequent heatwaves can trigger mass mortality of the foraging workforce. This leads to a unique form of social

collapse—the “zombie colony”—where the selective removal of a single caste dismantles the colony’s functional integrity.

For *Lestis aeratus*, the endangered specialist, the threat is amplified and indirect. Climate change acts as a threat multiplier, disrupting the delicate fire-succession dynamics required to produce its essential nesting resources. This “ecological desynchronisation,” combined with direct reproductive stress and a contracting climatic envelope, pushes an already vulnerable species closer to extinction.

9.2 Economic and Ecological Cascade Effects

These impacts extend beyond individual species to create potential cascade effects across Australia’s pollination networks. The economic implications are substantial: Australia’s pollination services represent \$4.6 billion in annual consumer and producer surplus, with crops worth \$12.9 billion partially reliant on bee services (Gordon & Davis, 2023). Even modest declines in pollinator abundance or effectiveness could trigger price increases, reduced agricultural productivity, and increased reliance on imported foods.

From an ecological perspective, the loss or reduction of native pollinators like *T. carbonaria* and *L. aeratus* could disrupt co-evolved plant-pollinator relationships that have persisted for millions of years. These native bees often provide specialised pollination services that introduced honeybees cannot replicate, making their conservation critical for maintaining ecosystem integrity and native plant biodiversity.

9.3 Translating Fractional Warming into Tangible Consequences

These case studies powerfully illustrate the core purpose of the “bee barometer” framework. They translate the abstract, seemingly negligible figures of fractional degree warming into tangible, scientifically plausible, and relatable ecological consequences. A projected warming of 0.0046°C as a result of the growth in global data centre energy becomes meaningful when it is understood as:

- A measurable 3-7% increase in the risk of queen fertility failure in managed honeybee colonies
- A 0.3-0.6% increase in the annual probability of mass forager mortality events in stingless bee populations
- An acceleration of fire-driven habitat loss for specialist cavity-nesting bees that could reduce available nesting sites by 5-10% per decade

These seemingly small percentage increases compound over time and across landscapes, creating cumulative pressures that can push vulnerable species past critical tipping points.

Table 3: Synthesis of Projected Climate Change Impacts on Selected Australian Bee

Species

Species	Primary Vulnerability Type	Key Stressor	Projected Impact (Constrained-Growth: +0.0026°C)	Projected Impact (Base Case: +0.0046°C)	Projected Impact (High-Growth: +0.0071°C)
<i>Apis mellifera</i> (European Honeybee)	Reproductive Health	Sub-lethal heat stress on queens and drones (>38°C)	Minor increase in risk of queen failure and reduced drone fertility (3-5% increase in annual failure rate)	Measurable increase in risk of queen failure; reduced mating success (5-8% increase in annual failure rate)	Significant increase in systemic risk of widespread queen failure, impacting industry stability (8-12% increase in annual failure rate)
<i>Tetragonula carbonaria</i> (Carbonaria Stingless Bee)	Social Structure Collapse	Acute lethal heat stress on foragers (>42°C)	Minor increase in frequency of forager mortality events (0.1-0.2% increase in annual risk)	Measurable increase in "zombie colony" events post-heatwave (0.3-0.6% increase in annual risk)	Significant increase in frequency of mass forager mortality, threatening local population viability (0.6-1.1% increase in annual risk)
<i>Lestis aeratus</i> (Green Carpenter Bee)	Habitat Loss (Threat Multiplier)	Climate-driven increase in fire frequency disrupting nesting substrate availability	Minor acceleration of habitat degradation (2-3% increase in unsuitable habitat per decade)	Measurable increase in fire frequency, further reducing long-term nesting refuges (3-5% increase in unsuitable habitat per decade)	Significant disruption of fire-succession cycle, increasing extinction risk in vulnerable populations (5-8% increase in unsuitable habitat per decade)

Note: Percentage estimates are based on scaling from observed relationships and should be considered indicative rather than precise predictions. Annual risk increases compound over time and may lead to non-linear population responses.

9.4 A numerical perspective on the European Honeybee

Apiculture means that the European Honeybee the best-known species in Australia. The effect of this can be expressed in terms of hives lost, if no adaptation occurs. There are about 870,000 hives in Australia (AgriFutures Australia, 2024). According to Gray et al. (2022), a 37-country average on “normal” queen failures is 4.5%. That is, 3,915 hives. Although the number of bees per hive varies by season, the queen failure will be highest in summer, when there are most bees in the hive. Conservatively assuming that the number of bees in a summer hive is 30,000, then the lost bees attributable to data centres is as set out in Table 4.

Table 4: European Honeybee deaths in the absence of adaptation

	Percentage annual failure rate increase									
	Best case			Base case			Worst case			
	3%	4%	5%	6%	7%	8%	9%	10%	11%	12%
Hives lost	117	157	196	235	274	313	352	392	431	470
Bees lost (million)	3.5	4.7	5.9	7.0	8.2	9.4	10.6	11.7	12.9	14.1

Part III: Strategic Responses and Future Pathways

10. Limitations and Uncertainties

10.1 Methodological Limitations

Temperature-Extreme Scaling Uncertainties: The methodology for translating global mean warming to local extreme frequency changes relies on empirically derived scaling factors that may not hold under future climate conditions. The amplification factor of 3.31 per degree of warming is based on observed historical relationships that could change as the climate system moves into novel states. Regional variations in this relationship are substantial, and the projections should be considered order-of-magnitude estimates rather than precise forecasts. The scaling of data centre growth has the same methodological limitation.

Species-Specific Data Gaps: While thermal tolerance data exists for the study species, comprehensive physiological studies under realistic field conditions are limited. Laboratory-derived critical thermal maxima may not accurately reflect field performance, where factors such as humidity, wind, and behavioural adaptations can modify thermal stress responses. Additionally, the potential for evolutionary adaptation over the 2024-2035 timeframe is not captured in these projections.

Synergistic Effects Not Modelled: This analysis focuses primarily on temperature effects but does not comprehensively model interactions with other climate variables (humidity, rainfall patterns, wind) or non-climate stressors (pesticides, habitat fragmentation, diseases, invasive species). These synergistic effects could either amplify or moderate the projected impacts in ways not captured by temperature-focused models.

Focus is on data centres, not other compute: There is a methodological limitation in that the report considers energy used in data centres and there are other sources of energy use in computing. It is useful to consider this for the US, the UK, and Australia.

There are two sources of energy use. The first is the amount of energy used in operation. The second is the “embodied energy”. That is, the energy used in the manufacture of the device. The report does not consider the embodied energy in data centres.

To understand these, Table 5 sets out the operational and annualised embodied energy for commonly used compute devices (smartphone, laptops, desktops, tablets). The figures indicate that the energy used in compute outside of data centres is comparable to that of data centres.

Table 5: Other sources of compute energy use

Country	Device Category	Estimated Number of Devices (Household and Workplace)	Annual Operational Energy (GWh)	Annualised Embodied Energy (GWh)
United States	Smartphones	366,379,200	7,456	36,638
	Laptops	228,406,200	17,816	71,377
	Desktops	93,764,200	21,941	9,067
	Tablets	146,908,000	4,584	10,090
US Total			51,797	127,172
United Kingdom	Smartphones	65,385,000	1,332	6,539
	Laptops	56,519,625	4,409	17,662
	Desktops	11,992,875	2,806	1,160
	Tablets	40,307,500	1,258	2,771
UK Total			9,805	28,132
Australia	Smartphones	30,702,000	626	3,070
	Laptops	19,568,200	1,526	6,115
	Desktops	8,798,800	2,059	851
	Tablets	12,365,000	386	850
Australia Total			4,597	10,886

The data in Table 5 was synthesised using a range of methodologies and sources. The total number of devices was estimated by combining national statistics on households and population with device penetration rates from market research and statistical reports. For the US, household and device ownership data were sourced from the U.S. Census Bureau (2021) and complemented with smartphone penetration rates from the Pew Research Center (2021). For the UK, data on household internet access and individual device use was sourced from the Office for National Statistics (2023), with market penetration trends provided by Deloitte (2022). For Australia, figures were based on data regarding household use of information technology from the Australian Bureau of Statistics (2021) and consumer trends from Deloitte (2022).

This Annual Operational Energy was calculated by multiplying the estimated number of devices by their average power consumption and typical annual usage hours. The calculation followed the formula: (Number of Devices × Average Power Consumption in kW × Average Annual Hours of Use). Models for average device power consumption (active and standby) and usage patterns were derived from comprehensive studies on the energy footprint of the ICT sector (Andrae & Edler, 2015; Malmodin & Lundén, 2018).

The Annualised Embodied Energy (GWh) represents the energy consumed during manufacturing and transport, annualised over the device's average lifespan. The calculation followed the formula: $(\text{Number of Devices} \times \text{Total Embodied Energy per Device}) / \text{Average Device Lifespan in Years}$. Data on the lifecycle energy assessment and total embodied energy for each device category was sourced from Malmodin & Lundén, (2018). Information on the average consumer lifespan for devices was informed by research on electronics longevity and repairability.

10.2 Ecological and Temporal Uncertainties

Adaptation Potential: The analysis assumes limited adaptation capacity based on current research showing that most bee species exhibit minimal thermal acclimation (averaging only 9% improvement) (Bennett et al., 2024). However, rapid evolutionary responses or behavioural adaptations could potentially moderate impacts, particularly for species with short generation times and high genetic diversity.

Fire Regime Modeling: The fire-climate projections for *L. aeratus* habitat rely on statistical relationships between climate variables and fire probability. These relationships are based on historical data and may not accurately capture the complex interactions between climate change, fire management practices, and vegetation dynamics under novel climate conditions.

Population-Level Responses: The analysis focuses on individual and colony-level responses but does not comprehensively model population-level dynamics, including migration, recolonization, and metapopulation effects that could influence species persistence under changing conditions.

11. Management Interventions and Adaptation Strategies

11.1 For Managed Honeybee Populations

Heat Stress Mitigation: Shade Provision: Establish shade structures over apiaries using natural vegetation or artificial covers. Research demonstrates that shade can reduce hive temperatures by 3-5°C during extreme heat events (Stabentheiner et al., 2010).

Water Source Management: Provide reliable water sources within 100m of apiaries. Colonies under thermal stress can double their water foraging activity, and nearby water sources reduce forager exposure time (Oregon State University Extension, 2023).

Improved Ventilation: Modify hive designs to enhance airflow and heat dissipation, including bottom screen boards, ventilation holes, and elevated hive placement to promote air circulation.

Breeding and Genetic Management: Heat-Tolerant Stock Development: Prioritize breeding programs that select for heat tolerance and reproductive resilience under thermal stress. International programs have identified genetic markers associated with thermal tolerance that could be incorporated into Australian breeding efforts (Uzunov et al., 2022).

Genetic Diversity Maintenance: In the US, 94% of honeybees belong to a single evolutionary lineage (USDA ARS, 2023). The genetic diversity is much greater in Australia (Chapman et al., 2016). However, some of that diversity is supported by feral bees. The genetic diversity is much greater in Australia (Chapman et al., 2016). However, some of that diversity is supported by feral bees. Feral bees are susceptible to varroa mite as there is currently no miticide for feral bees (Owen et al., 2022). Protecting feral bees from varroa and importing diverse genetic material and maintaining breeding programs with multiple lineages could enhance thermal resilience.

Integrated Pest and Disease Management: Climate-stressed colonies are more susceptible to pests and diseases. Proactive monitoring and treatment protocols for Varroa mites, Nosema, and other pathogens become increasingly important as thermal stress compromises immune function.

11.2 For Native Bee Conservation

Habitat Restoration and Enhancement: Post-Fire Recovery Programs: Expand successful bee hotel programs that achieved 100% occupancy in post-fire trials (Wilson & Smith, 2024). Strategic placement of artificial nesting sites can provide immediate habitat while natural substrates recover.

Fire Management Integration: Develop fire management plans that explicitly consider bee habitat requirements, maintaining landscape mosaics with varied fire histories to support both short-term (*Xanthorrhoea*) and long-term (*Banksia*) nesting resources.

Native Plant Restoration: Habitat restoration programs should prioritize native plant species that provide heat-tolerant nectar and pollen sources throughout the extended warm season. Meta-analyses show that native plant diversity is the strongest predictor of bee community recovery (Tonietto et al., 2018).

Assisted Migration and Translocation: Climate Refugia Identification: Map and protect potential climate refugia where vulnerable species like *L. aeratus* might persist under warming scenarios. High-elevation sites and areas with favourable microclimates should receive priority conservation attention.

Translocation Programs: For critically endangered species, carefully planned translocation programs could establish populations in climatically suitable areas within their historical range. Genetic screening should ensure translocated individuals carry heat-tolerance traits.

11.3 Landscape-Scale Interventions

Urban Heat Island Mitigation: In urban and suburban areas where many managed bee colonies are located, green infrastructure and urban forestry programs can reduce local temperatures by 2-5°C, providing important thermal refugia (Youngsteadt et al., 2017).

Connectivity Enhancement: Create habitat corridors that enable bee populations to track suitable climate conditions as they shift across the landscape. This is particularly important for mobile species that can potentially migrate to cooler areas.

Multi-Stakeholder Coordination: Develop regional bee conservation strategies that coordinate efforts across government agencies, research institutions, beekeeping organizations, and conservation groups. Climate adaptation requires landscape-scale coordination that transcends individual property boundaries.

12. Corporate Incentives and Grid Independence Strategies.

12.1 The Economic Case for Energy Independence

The most powerful incentives for Big Tech to invest in private renewable energy infrastructure are rooted in strategic self-interest: controlling costs, ensuring supply resilience, and capitalizing on substantial government incentives. Public grids are facing increasing strain, with connection queues for new large loads stretching for years in some jurisdictions, creating unacceptable business risks for an industry that demands near-100% uptime (Canary Media, 2025).

Government policies like the U.S. Inflation Reduction Act have fundamentally altered the economic calculus, providing a suite of financial incentives that make private investment in clean energy highly profitable. This is shown in Table 6.

Table 6: An altered economic calculus

Incentive	Description	Value/Impact for Corporate Investor
Investment Tax Credit (ITC)	A tax credit based on a percentage of the capital investment in a renewable energy system	Base credit of 30% for projects meeting wage requirements. Can be monetized via direct pay or transferability
Production Tax Credit (PTC)	A per-kilowatt-hour tax credit for electricity generated by a renewable facility	Base credit of \$2.75/kWh (2023 value) for projects meeting wage requirements
Bonus Adders	Additional percentage points can be added to the ITC for meeting specific criteria	+10% for using domestic content; +10% for siting in a designated "Energy Community." Credits can be "stacked" to significantly increase project ROI

These policies offer a clear template for aligning corporate self-interest with public climate goals, demonstrating that financial incentives can be more effective than sustainability messaging in driving systemic change.

13. Industry Leadership in Sustainable Digital Infrastructure

The transformation of the data centre industry from passive energy consumer to active participant in the clean energy transition requires coordinated action across multiple dimensions. This section outlines how data centre operators, cloud service providers, and corporate customers can build sustainable digital infrastructure whilst maintaining competitive advantage.

13.1 Energy Independence and Carbon-Free Operations

The business case for data centre operators to invest in private renewable energy infrastructure has shifted from sustainability aspiration to strategic necessity. Grid constraints, government incentives, and evolving customer expectations have created an economic rationale for energy independence.

Operators should move beyond annual renewable energy certificates toward genuine 24/7 carbon-free energy matching. Early adopters will gain competitive advantage as corporate customers increasingly demand verified sustainability credentials. Google's progress toward 90% hourly carbon-free energy demonstrates this goal is achievable. The key lies in co-locating data centres with dedicated renewable generation and storage capacity, eliminating transmission constraints whilst reducing grid strain.

Carbon-aware computing offers immediate emissions reductions without new capital expenditure. By shifting flexible workloads to times and locations with lower grid carbon intensity, operators can reduce emissions by 20-40% through intelligent scheduling alone. AI model training, batch processing, and data analytics are ideal candidates for this approach.

13.2 Operational Excellence and Transparency

Efficiency improvements remain essential for cost management and absolute emissions reduction, despite the Jevons Paradox. Operators should optimise cooling systems, deploy liquid cooling for AI workloads, and conduct regular energy audits. Transparent reporting and independent verification of environmental claims are essential. Vague commitments and unverifiable purchases are no longer acceptable.

Data centre operators should adopt and publicly report hourly carbon-free energy scores, providing stakeholders with accurate sustainability metrics. The ISO/IEC 21031:2024 standard for software carbon intensity provides a methodology for measuring computational carbon footprints. Early adoption positions operators as industry leaders whilst building reporting infrastructure that will soon become mandatory.

13.3 Strategic Siting and Ecological Responsibility

Data centre siting must expand beyond connectivity, power availability, and land costs to incorporate comprehensive environmental assessment including climate vulnerability, extreme weather risks, water constraints, and impacts on biodiversity. Operators should prioritise brownfield sites over greenfield development. Where new development is unavoidable, biodiversity surveys should precede construction with habitat restoration integrated into facility design.

Demand-response capabilities transform data centres from static grid liabilities into valuable dynamic assets. Facilities with flexible load management can curtail non-essential workloads during extreme demand, providing grid operators with responsive capacity. This generates revenue through capacity markets whilst demonstrating corporate citizenship.

For new large-scale facilities exceeding 100 megawatts, operators should voluntarily adopt a "conditional access" approach: capping grid draw at sustainable levels, constructing additional renewable generation for excess demand, and implementing energy storage and load management for grid independence. Whilst requiring higher initial investment, this eliminates connection delays and provides long-term cost certainty.

13.4 Corporate Customers as Market Transformers

Corporate data centre customers possess significant market power to drive industry transformation through procurement decisions. This power has been underutilised, with organisations selecting providers based primarily on cost, performance, and reliability whilst treating sustainability as secondary.

When evaluating providers, corporate customers should prioritise vendors demonstrating verified 24/7 carbon-free energy with hourly accounting rather than annual renewable energy purchases. Hourly matching requires genuine investment in storage and operational flexibility that delivers actual emissions reductions. Transparent reporting should be non-negotiable, with providers publicly disclosing comprehensive environmental metrics subject to third-party verification.

Sustainability criteria should be formally incorporated into request-for-proposal processes with 15-25% weighting. Beyond vendor selection, corporate customers should implement carbon-aware development practices, optimise code for energy efficiency, and leverage geographic distribution to route flexible workloads to cleaner grids. Regular audits typically reveal 30-40% of provisioned capacity sits idle. This waste elimination delivers immediate savings alongside emissions reductions.

14. Pathways to Transformation: A Phased Implementation Framework

The transformation toward genuine sustainability requires systematic change through coordinated phases, with each stage building upon previous achievements whilst preparing for subsequent advances.

14.1 Immediate Actions: The First Twelve Months

Data centre operators should begin with comprehensive energy audits identifying efficiency improvements across their portfolio. These must extend beyond meter readings to include thermal imaging, airflow analysis, and cooling system optimisation. Simultaneously, operators should initiate transition to hourly carbon accounting and reporting frameworks, requiring investment in metering infrastructure and data management systems.

Implementation of carbon-aware workload scheduling for flexible computing represents another immediate priority. AI model training, data analytics, and batch processing can shift to periods of lower grid carbon intensity without impacting service quality. Operators should establish renewable energy procurement strategy, issuing requests for proposals for on-site or proximate generation projects. Ecological impact assessments should evaluate climate vulnerability, water constraints, and impacts on sensitive ecosystems.

Corporate customers should add detailed sustainability criteria to provider evaluation processes, demanding specific verifiable performance metrics. This includes comprehensive audits of current data centre energy consumption establish baseline metrics for indirect emissions throughout the value chain. Optimising cloud infrastructure by eliminating idle resources delivers rapid cost savings.

14.2 Medium-Term Initiatives: Years One Through Three

This phase focuses on capital-intensive projects requiring sustained investment. Operators should complete first-phase renewable generation projects, bringing capacity meeting at least 30-50% of facility demand online. Advanced cooling technologies for high-density AI workloads become essential, with liquid cooling systems delivering superior efficiency for GPU clusters.

Deployment of grid-interactive capabilities transforms facilities from passive consumers to active grid participants, requiring energy storage systems, intelligent load management, and real-time grid integration. Partnerships with conservation organisations for biodiversity offset programs extend environmental responsibility beyond carbon metrics. Third-party verification of environmental claims builds trust with customers and regulators.

Corporate customers should migrate at least half their workloads to verified sustainable providers, implement carbon-aware computing across development teams, and target 30% reduction in per-workload energy consumption through optimisation.

14.3 Long-Term Transformation: Years Three Through Five and Beyond

Operators should target 80% or higher hourly carbon-free energy across their entire portfolio, requiring substantial renewable capacity, sophisticated storage, and operational excellence. Demonstrating net-positive or neutral impact on local ecosystems represents a radical departure from traditional industrial development, requiring long-term commitment to habitat restoration and species protection.

Leadership in transparent, verified environmental reporting should encompass direct operational metrics, supply chain emissions, water consumption, and biodiversity impacts. The transformation into grid stabilisation assets through flexible load management represents the culmination of the journey from passive consumer to active energy system participant.

Corporate customers should achieve 100% sustainable data centre sourcing, though this should be recognised as a baseline rather than endpoint. The more ambitious goal is demonstrating measurable reductions in total digital carbon footprint despite business growth. Integration of carbon intensity into all technology architecture decisions represents a fundamental shift in how organisations approach digital infrastructure.

14.4 Innovation Imperatives for Industry Leadership

Genuine sustainability requires continuous innovation across multiple technical domains. Industry should invest in next-generation efficiency technologies including advanced liquid cooling systems, novel heat recovery approaches, and ambient cooling techniques. Carbon-aware computing frameworks need development to move from hyperscale demonstration projects to widely available tools accessible to smaller organisations.

Renewable energy integration requires innovation in on-site generation and storage optimisation. Grid-interactive facility management platforms must balance multiple objectives through sophisticated real-time optimisation. Ecological impact assessment methodologies require further development to become standardised tools. The “bee barometer” framework developed in this report demonstrates how fractional global warming can be translated into

specific consequences for vulnerable species, requiring expansion to other taxa and ecosystems.

14.5 Measuring Progress: Comprehensive Performance Indicators

Achievement of sustainable digital infrastructure requires robust measurement systems tracking progress across multiple dimensions. Industry should adopt comprehensive metrics extending beyond traditional energy and carbon accounting to encompass operational excellence, ecological impact, and business value creation.

Understanding Emissions Scopes

The Greenhouse Gas Protocol (World Resources Institute & World Business Council for Sustainable Development, 2015) establishes three categories for classifying organisational emissions. Scope 1 encompasses direct emissions from owned or controlled sources. Scope 2 covers indirect emissions from purchased electricity, steam, heating, or cooling. Scope 3 includes all other indirect emissions throughout the value chain. This taxonomy is particularly relevant for understanding how corporate procurement decisions drive industry transformation, as emissions that constitute Scope 2 for data centre operators become Scope 3 for their customers.

Energy and carbon metrics form the foundation but must evolve toward hourly granularity. Hourly carbon-free energy percentage reflects actual grid impact. Annual Power Usage Effectiveness indicates operational efficiency. Absolute carbon emissions across all Scopes provide the bottom-line metric for climate impact. Renewable energy capacity owned or contracted demonstrates tangible investment in carbon-free generation. Carbon intensity per compute unit enables meaningful comparison across facilities.

Operational metrics extend beyond energy to resource efficiency and waste management. The ratio of grid draw to on-site generation indicates progress toward energy independence. Water usage effectiveness becomes increasingly critical as climate change intensifies water scarcity. Electronic waste recycling rates demonstrate environmental responsibility across the full product lifecycle.

Ecological impact metrics represent the frontier of comprehensive environmental performance. Biodiversity assessments should track species abundance, habitat quality, and ecosystem health over time. Habitat restoration investments provide evidence of commitment to ecological stewardship. Climate adaptation measures demonstrate long-term resilience planning.

Business value metrics demonstrate that environmental excellence and commercial success are mutually reinforcing. Customer sustainability requirement fulfilment rate tracks ability to meet evolving market demands. Premium pricing captured for sustainable services quantifies commercial value of environmental leadership. Energy cost volatility reduction measures financial benefits of renewable investments. Brand value from sustainability leadership manifests through customer retention, regulatory treatment, and talent attraction.

This comprehensive measurement framework enables operators and customers to track progress, identify opportunities for improvement, and demonstrate genuine environmental leadership through verified, transparent reporting of meaningful metrics.

15. Conclusions: Bridging the Digital-Ecological Divide

This analysis has bridged the gap between abstract global climate projections and tangible ecological consequences. It has demonstrated how the exponential growth of AI-driven data centres contributes to measurable risks for Australia's key pollinator communities. The integrated "digital climate footprint" framework reveals that technology's environmental impact extends far beyond carbon accounting to encompass real threats to biodiversity, ecosystem services, and agricultural stability.

15.1 Key Findings and Strategic Insights

The Scale of the Challenge: Global data centre growth between 2024 and 2035 could contribute 4.8 to 15.4 gigatonnes of cumulative CO₂ emissions, representing 1% to 19% of the world's remaining carbon budget for 1.5°C warming. This technological subsector is introducing new emissions during the decade when deep reductions are required across all other sectors.

The Non-Linear Nature of Ecological Risk: The relationship between global mean warming and local ecological impact is profoundly non-linear. Fractional degree warming translates into measurable increases in extreme heat events that push vulnerable species past critical physiological thresholds. The "bee barometer" demonstrates how 0.0046°C of warming becomes a 5-8% increase in queen fertility failure risk—a material threat to agricultural stability.

Species-Specific Vulnerability Pathways: Different species face distinct threats under the same warming scenarios. Managed honeybees risk reproductive failure that threatens agricultural productivity, native stingless bees face acute mortality leading to social collapse, and specialist carpenter bees confront climate-amplified habitat destruction. This diversity of vulnerability patterns underscores the need for targeted, species-specific conservation strategies.

Economic Materiality: The \$4.6 billion annual value of Australia's bee-dependent agriculture faces quantifiable risks from climate-driven pollinator stress. Even modest declines in pollinator health could trigger significant economic impacts across food supply chains, making this an immediate concern for agricultural policy and risk management.

The Opportunity for Integrated Solutions: The analysis reveals multiple intervention points where technology innovation, conservation action, and policy reform can converge to address the challenges. From heat-resistant bee breeding programs to carbon-aware computing strategies and phased implementation frameworks, solutions exist that can simultaneously advance technological progress and environmental protection. The transformation pathway from immediate actions through to long-term systemic change demonstrates that sustainable digital infrastructure is both technically feasible and economically viable.

15.2 The Broader Implications: Technology, Ecology, and Sustainability

This analysis illustrates the complex, cascading, and often indirect pathways through which technological growth affects natural systems. Australia exemplifies this complexity as both a major fossil fuel exporter (4.5% of global emissions) and a climate-vulnerable nation, creating feedback loops where export revenues fund economic growth while the resulting emissions damage domestic infrastructure and ecosystems. The integrated framework provides a model for understanding how decisions made in technology boardrooms ultimately influence ecosystem health, agricultural productivity, and biodiversity conservation.

The Need for Ecological Intelligence in Technology Planning: The technology sector must evolve beyond narrow carbon metrics to embrace comprehensive ecological impact assessment. Data centre siting, energy procurement, and operational decisions should explicitly consider their downstream effects on vulnerable ecosystems and species. The measurement framework developed in this report, encompassing energy metrics, operational efficiency, ecological impacts, and business value, provides a template for integrated environmental performance assessment.

The Power of Market-Driven Transformation: Corporate procurement decisions possess significant untapped power to drive industry change. When customers incorporate verified sustainability criteria into vendor selection with meaningful weighting (15-25% of evaluation), they create market incentives more powerful than voluntary corporate programs alone. This customer-driven transformation, combined with phased implementation strategies, offers a practical pathway from current practices to genuinely sustainable operations.

The Urgency of Proactive Conservation: With temperature-related impacts projected to intensify rapidly through the 2020s and 2030s, conservation interventions must begin immediately. The near-term period (2024-2030) drives the largest annual emissions contributions across all scenarios, making actions taken in the next five years disproportionately important. Waiting for more definitive data or technological solutions risks missing key windows for action.

The Value of Integrated Assessment: The success of the “bee barometer” framework in translating abstract climate data into tangible biological consequences demonstrates the value of interdisciplinary approaches that connect global environmental changes to local ecological realities.

15.3 A Call for Coordinated Action

The race between exponential technological advancement and environmental stewardship is not a future concern but a present reality requiring immediate, coordinated action. This analysis demonstrates that:

For Policymakers: Climate adaptation strategies must explicitly include biodiversity and ecosystem service protection. Carbon pricing and environmental regulations should capture the full ecological costs of digital infrastructure growth. Conditional grid access policies that cap public grid draw while mandating private renewable generation for large facilities can transform data centres from grid liabilities into clean energy catalysts, creating market-based incentives for 24/7 carbon-free energy solutions.

For Technology Operators: Energy independence has shifted from sustainability aspiration to strategic necessity. Grid constraints and substantial government incentives, including tax

credits up to 30% for renewable investments, make private renewable generation economically compelling. The phased implementation framework, from immediate energy audits and carbon-aware computing through to long-term 24/7 carbon-free operations, provides a practical roadmap for transformation. Transparent reporting using comprehensive metrics across Scope 1, 2, and 3 emissions builds stakeholder trust and positions early adopters as industry leaders.

For Corporate Customers: Market power to drive industry transformation through procurement decisions remains largely untapped. Incorporating verified sustainability criteria with meaningful weighting into vendor selection, demanding hourly carbon accounting rather than annual renewable energy purchases, and implementing carbon-aware development practices can create more powerful incentives for change than voluntary corporate programs. Customer-driven transformation represents the fastest pathway to systemic industry change.

For Conservation Scientists: Traditional conservation approaches must be supplemented with climate-informed strategies that anticipate and prepare for changing environmental conditions. The synergistic threats revealed by this analysis, where heat stress amplifies disease impacts by 46-67% through metabolic disruption, demonstrate that climate impacts accelerate beyond simple temperature effects. Proactive intervention addressing these complex interactions is more effective than reactive response.

For Agricultural Stakeholders: Pollinator conservation is climate adaptation. Investing in bee habitat, breeding programs, and monitoring systems protects the biological foundation of agricultural productivity.

15.4 The Path Forward: Technology in Service of Life

The projected impacts on Australia's pollinators are not inevitable. They represent one possible future under current technological and policy trajectories. Alternative pathways exist through coordinated implementation across immediate, medium-term, and long-term timeframes:

In the immediate term (first 12 months), operators can implement comprehensive energy audits, transition to hourly carbon accounting, deploy carbon-aware workload scheduling, and establish renewable energy procurement strategies. Corporate customers can add detailed sustainability criteria to provider evaluations and audit current infrastructure for optimisation opportunities.

Through medium-term initiatives (years one through three), operators can bring substantial renewable generation capacity online, deploy advanced cooling technologies, and establish grid-interactive capabilities. Corporate customers can migrate workloads to verified sustainable providers and implement carbon-aware computing across development teams. Long-term transformation (years three through five and beyond) enables operators to achieve 80% or higher hourly carbon-free energy, demonstrate net-positive ecological impacts, and become active grid stabilisation assets. Corporate customers can achieve complete sustainable sourcing whilst demonstrating measurable reductions in total digital carbon footprint despite business growth.

Australia's position as both a climate-vulnerable nation and fossil fuel exporter creates unique opportunities for policy innovation. The country's exceptional vulnerability to warming (1.51°C increase since 1910) combined with emerging corporate incentives for grid independence could establish global precedents for sustainable data centre development. The convergence of artificial intelligence, climate change, and biodiversity loss represents one of the defining challenges of our time. This analysis demonstrates that we possess the

scientific understanding, technological capabilities, policy tools, and implementation frameworks needed to navigate this challenge successfully. What remains is the collective will to implement integrated solutions at the scale and speed required.

The bees, and the ecosystems they support, serve as sentinels of environmental change. Their response to the digital climate footprint provides an early warning system for broader ecological risks. The synergistic threats revealed, where heat stress amplifies disease impacts through metabolic disruption, demonstrate how climate impacts accelerate beyond simple temperature effects, making coordinated action across the phased implementation framework even more critical.

The future of digital technology and ecological integrity need not be in conflict. Through thoughtful integration of environmental considerations into technology planning, strategic investments in conservation and renewable energy, coordinated policy responses spanning sectors and scales, and systematic implementation guided by comprehensive performance metrics, we can build a future where computational power serves both human advancement and planetary health.

The bee barometer points not toward inevitable decline, but toward the urgent need for integrated action. The technology that created the challenge can also provide the solutions, and the frameworks for implementing those solutions now exist. The question is whether we have the wisdom and resolve to implement them in time.

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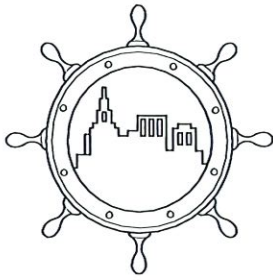
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MEMORANDUM

To: Sparta Township Planning Commission
From: Kevin Yeomans
Date: 3/2/2026
Re: Home Occupation Regulations Review

Per the Planning Commission's preliminary conversations at your January 2026 meeting, we have prepared draft language that will update Home Based Occupation regulations. Based on your preliminary conversations it's our understanding that you may want to allow more flexibility for Home Based Occupations, such as use of an accessory building, without expanding the regulations so far as to allow substantial adverse impacts to surrounding residential uses, such as substantial increase in traffic, noise, odors, or visual impacts.

As part of our work in preparing the draft regulations, we reviewed regulations from Allendale Charter Township, Chester Township, and Jamestown Charter Township. A copy of these regulations have been attached to this memorandum.

Items for Consideration

Attached is a draft of updated home occupation regulations for your review. This draft is not meant to be exhaustive, nor is it meant to be a final draft. The purpose of the draft, along with the samples provided, is intended to act as a starting point for your deliberations. We encourage the Planning Commission to review all the proposed language but have also provided the following items to bring to your attention.

New Terminology

Following the example from Chester Township we have proposed creating a new term for businesses that would be operated, in part or whole, from an accessory building. The new term is Home Based Business.

The impact would be that a Home Occupation operates solely out of a dwelling and remains a use by right. Whereas a Home Based Business would also be operated, in whole or part, from an accessory building and only allowed as a special land use.

Use by Right v. Special Land Use

As proposed, all Home Based Business would be a special land use. The Planning Commission should determine if this should be the case or if there are certain criteria where a Home Based Business could be a use by right.

For example, if an electrical contractor only has one truck, one trailer, and all other equipment is stored inside the accessory building, could this be a use by right. Alternatively, what if a property owner operates a custom furniture making business from their pole barn. While materials and equipment may be stored and operated indoors, the noise and fumes generated by the use may require additional restrictions that can only be cleanly, applied through a special land use.

Family Members Only

Using provisions that already exist for Home Occupations, we have included provisions that only allow family members residing on the property to be employed by the Home Based Business. Some communities do allow additional employees, but when additional employees

are allowed there is usually a limit to how many more. The Planning Commission should determine if additional employees will be allowed.

Where Allowed

In the draft language we identified home based businesses as being allowed in the Ag-1, Ag-2, and R-1 districts. The Planning Commission should determine whether Home Based Businesses should also be allowed in the R-2: Medium Density Single Family, R-3 Medium-High Density: Multiple Family, of R-4 Medium-High Density: Mobile Home Park districts.

Maximum Floor Area

When a Home Based Business grows beyond what was intended, issues can arise. To help address these issues we have recommended including a maximum floor area to limit how large or how much of an accessory building can be used as part of a Home Based Business. We have inserted 1,234 square feet as a starting point for discussion.

If the Planning Commission determines that all Home Based Businesses should be a special land use, this provision may not be necessary.

Outdoor Storage

In our experience, outdoor storage tends to be an item that results in the most adverse impacts for a Home Based Business. Some communities completely prohibit it, where others allow limited outdoor storage if it is landscaped and/or screened appropriately.

In the draft provided, we have prohibited outdoor storage with limited exceptions for motor vehicles and trailers. We seek the Planning Commission's direction on whether outdoor storage would be appropriate.

List of example uses

Similar to Home Occupations we have prepared a list of example uses. The Planning Commission should review this list and determine if any changes need to be made. If no outdoor storage is permitted the Planning Commission may want to remove excavators from the list of allowed examples.

We have no other specific items to bring to the Planning Commission's attention.


Kevin Yeomans

Planner

Attachments

CC: Dale Bergman, Township Supervisor

Definition – Section 154.006

HOME OCCUPATION. A profession or other occupation not otherwise permitted in the zoning district involved, that is conducted as an accessory use within a single-family dwelling by one or more members of the family residing in the dwelling, and that conforms to the provisions of § 154.208 of this chapter.

§ 154.208 HOME OCCUPATIONS.

Home occupations, as defined in this chapter, are permitted as an accessory use as provided in § 154.247 of this chapter; provided that, all of the following regulations shall control.

- (A) No other than members of the family residing in the dwelling shall be engaged in connection with such home occupation at the same time.
- (B) The use of the dwelling unit for the home occupation shall be clearly incidental and subordinate to its use for residential purposes by its occupants and not more than 25% of the floor area of the dwelling unit shall be used in the conduct of the home occupation.
- (C) There shall be no change in the outside appearance of the building, no variation from the residential character of the dwelling, and no visible evidence of the conduct of such home occupation other than one sign, not exceeding two square feet in area, non-illuminated and mounted flat against the wall of the main building.
- (D) No home occupation shall be conducted outdoors or in any accessory building.
- (E) There shall be no sale of products or services, except as are produced on the premises by such home occupation.
- (F) No traffic shall be generated by such home occupation in greater volumes than would normally be expected in a residential neighborhood, and any need for parking generated by the conduct of such home occupation shall be met off the street and other than in a required front yard.
- (G) No equipment or process shall be used in such home occupation that creates noise, vibration, glare, fumes, odors or electrical interference detectable to the normal senses off the premises if the occupation is conducted in a single-family dwelling. If conducted in other than a single-family dwelling, such nuisance shall not be detectable outside the dwelling unit. In the case of electrical interference, no equipment or process shall be used that creates visual or audible interference in any radio or television receivers off the premises or cause fluctuations in line voltage off the premises.
- (H) In particular, a home occupation can be, but is not limited to: art studio; dressmaking; teacher, with musical or dancing instruction limited to four to six pupils at a time; contractor's office; professional office or studio or a physician, dentist, author, artist, musician, lawyer, engineer, architect, community planner, realtor, accountant, one-chair

Sparta Township
Current Home Occupation Regulations
3/2/2026

salon or similar use; but shall not include animal hospital, automotive repair service, restaurant, tearoom, tavern or similar use.

(Ord. passed 7-12-2012, § 8.4; Ord. 24-1, passed 6-13-2024, § 1) Penalty, see § 154.999

CURRENT

Definition – Section 154.006

Home Based Business

This is similar to a Home Occupation but can be conducted both in a single-family residential dwelling and an accessory building if approved as a special land use by the Planning Commission.

HOME OCCUPATION. A profession or other occupation not otherwise permitted in the zoning district involved, that is conducted as an accessory use within a single-family dwelling by one or more members of the family residing in the dwelling, and that conforms to the provisions of § 154.208 of this chapter.

§ 154.208 HOME OCCUPATIONS AND HOME BASED BUSINESSES.

(A) Home occupations, as defined in this chapter, are permitted as a use-by-right as an accessory use as provided in § 154.247 of this chapter; provided that, all of the following regulations shall control.

- (1) No other than members of the family residing in the dwelling shall be engaged in connection with such home occupation at the same time.
- (2) The use of the dwelling unit for the home occupation shall be clearly incidental and subordinate to its use for residential purposes by its occupants and not more than 25% of the floor area of the dwelling unit shall be used in the conduct of the home occupation.
- (3) There shall be no change in the outside appearance of the building, no variation from the residential character of the dwelling, and no visible evidence of the conduct of such home occupation other than one sign, not exceeding two square feet in area, non-illuminated and mounted flat against the wall of the main building.
- (4) No home occupation shall be conducted outdoors or in any accessory building.
- (5) There shall be no sale of products or services, except as are produced on the premises by such home occupation.
- (6) No traffic shall be generated by such home occupation in greater volumes than would normally be expected in a residential neighborhood, and any need for parking generated by the conduct of such home occupation shall be met off the street and other than in a required front yard.
- (7) No equipment or process shall be used in such home occupation that creates noise, vibration, glare, fumes, odors or electrical interference detectable to the normal senses off the premises if the occupation is conducted in a single-family dwelling. If conducted in other than a single-family dwelling, such nuisance shall not be detectable outside the dwelling unit. In the case of electrical interference, no equipment or process shall be

used that creates visual or audible interference in any radio or television receivers off the premises or cause fluctuations in line voltage off the premises.

(8) In particular, a home occupation can be, but is not limited to: art studio; dressmaking; teacher, with musical or dancing instruction limited to four to six pupils at a time; contractor's office; professional office or studio or a physician, dentist, author, artist, musician, lawyer, engineer, architect, community planner, realtor, accountant, one-chair salon or similar use; but shall not include animal hospital, automotive repair service, restaurant, tearoom, tavern or similar use.

(B) Home Based Businesses, as defined in this Chapter, are permitted as a special land use as an accessory use as provided in § 154.247 of this chapter; provided that, all of the following regulations shall control.

- (1) Home Based Businesses shall meet all of the requirements for a Home Occupation.
- (2) No other than members of the family residing in the dwelling shall be engaged in connection with such home occupation at the same time.
- (3) There shall be no sale of products or services, except as are produced on the premises by such home occupation.
- (4) There shall be no change in the outside appearance of the building, no variation from the residential character of the dwelling, and no visible evidence of the conduct of such home occupation other than one sign, not exceeding two square feet in area, non-illuminated and mounted flat against the wall of the main building.
- (5) No traffic shall be generated by such home occupation in greater volumes than would normally be expected in a residential neighborhood, and any need for parking generated by the conduct of such home based business shall be met off the street and other than in a required front yard.
- (6) No equipment or process shall be used in such home based business that creates noise, vibration, glare, fumes, odors or electrical interference detectable to the normal senses off the premises.
- (7) Districts Allowed:
 - (a) Ag-1
 - (b) Ag-2
 - (c) R-1
- (8) Minimum Lot Area
 - (a) Ag-1

- (b) Ag-2
 - (c) R-1
- (9) A Home Based Business may occur within the single-family dwelling and not more than one accessory building located on the same lot as the single-family dwelling.
- (10) The use of the dwelling unit or accessory building for the home based business shall be clearly incidental and subordinate to its use for residential purposes by its occupants.
- (11) Maximum Floor Area
- (a) Dwelling: Not more than 25% of the floor area of the dwelling unit shall be used in the conduct of the home based business.
 - (b) Accessory Building: Not more than 1,234 square feet of floor area within an accessory building shall be used in the conduct of the home based business.
- (12) Setbacks
- (a) Dwelling: Shall meet the setback requirements for a single-family dwelling as required by the zoning district.
 - (b) Accessory Building: Shall meet the setback requirements for an accessory building as required by the zoning district. However, in their review of the special land use the Planning Commission may required greater setbacks and/or additional landscaping and/or screening between the accessory building and adjoining properties and/or road to ensure that home based business will have no substantial adverse impacts by reason of noise, fumes, vibration, lights, or views.
- (13) No toxic or hazardous materials may be used or stored on the premises to support such Home Based Business except in a safe manner and in full compliance with federal, state, and local requirements as to use, handling, storage, transport, and disposal of any such materials.
- (14) All machinery and other equipment, associated with the Home Based Business must, at all times, be located within a completely enclosed accessory building, accessory to the residential dwelling which is on the same parcel as the business.
- (15) Outdoor Storage: No visible outdoor storage is permitted.
- (a) Motor Vehicles: All vehicles associated with the home based business shall comply with all applicable provisions of Section 154.260 of this

Chapter. No more than three (3) vehicles associated with the home based business shall be parked outdoors.

1. For the purposes of this section the term Motor Vehicle shall mean any vehicle of motor vehicle which can be started, drawn by its own power and legally operated on public streets or highways, not including heavy machinery such as excavators, bulldozers, loaders, cranes, and dump trucks.

(b) Trailers: All trailers associated with the home based business shall comply with all applicable provisions of Section 154.260 of this Chapter. No more than two (2) trailers associated with the home based business shall be parked outdoors.

1. For the purposes of this section the term Trailer shall mean a vehicle designed to be drawn by a motor vehicle for transporting equipment and materials.

(16) In particular, a home based business can be, but is not limited to: electrical, plumbing, heating, landscaping, and building contractors and excavators or similar use; but shall not include warehousing, distribution, or automotive repair.

NOTE: Review and, if necessary, update table of permitted uses.

Definition – Section 154.006

Home Based Business

This is similar to a Home Occupation but can be conducted both in a single-family residential dwelling and an accessory building if approved as a special land use by the Planning Commission.

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§ 154.208 HOME OCCUPATIONS AND HOME BASED BUSINESSES.

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~~(B)~~~~(2)~~ The use of the dwelling unit for the home occupation shall be clearly incidental and subordinate to its use for residential purposes by its occupants and not more than 25% of the floor area of the dwelling unit shall be used in the conduct of the home occupation.

~~(C)~~~~(3)~~ There shall be no change in the outside appearance of the building, no variation from the residential character of the dwelling, and no visible evidence of the conduct of such home occupation other than one sign, not exceeding two square feet in area, non-illuminated and mounted flat against the wall of the main building.

~~(D)~~~~(4)~~ No home occupation shall be conducted outdoors or in any accessory building.

~~(E)~~~~(5)~~ There shall be no sale of products or services, except as are produced on the premises by such home occupation.

~~(F)~~~~(6)~~ No traffic shall be generated by such home occupation in greater volumes than would normally be expected in a residential neighborhood, and any need for parking generated by the conduct of such home occupation shall be met off the street and other than in a required front yard.

~~(G)~~~~(7)~~ No equipment or process shall be used in such home occupation that creates noise, vibration, glare, fumes, odors or electrical interference detectable to the normal senses off the premises if the occupation is conducted in a single-family dwelling. If conducted in other than a single-family dwelling, such nuisance shall not be detectable outside the dwelling unit. In the case of electrical interference, no equipment or process

shall be used that creates visual or audible interference in any radio or television receivers off the premises or cause fluctuations in line voltage off the premises.

~~(H)(8)~~ In particular, a home occupation can be, but is not limited to: art studio; dressmaking; teacher, with musical or dancing instruction limited to four to six pupils at a time; contractor's office; professional office or studio or a physician, dentist, author, artist, musician, lawyer, engineer, architect, community planner, realtor, accountant, one-chair salon or similar use; but shall not include animal hospital, automotive repair service, restaurant, tearoom, tavern or similar use.

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(7) Districts Allowed:

(a) Ag-1

(b) Ag-2

(c) R-1

(8) Minimum Lot Area

(a) Ag-1

(b) Ag-2

(c) R-1

(9) A Home Based Business may occur within the single-family dwelling and not more than one accessory building located on the same lot as the single-family dwelling.

(10) The use of the dwelling unit or accessory building for the home based business shall be clearly incidental and subordinate to its use for residential purposes by its occupants.

(11) Maximum Floor Area

(a) Dwelling: Not more than 25% of the floor area of the dwelling unit shall be used in the conduct of the home based business.

(b) Accessory Building: Not more than 1,234 square feet of floor area within an accessory building shall be used in the conduct of the home based business.

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(13) No toxic or hazardous materials may be used or stored on the premises to support such Home Based Business except in a safe manner and in full compliance with federal, state, and local requirements as to use, handling, storage, transport, and disposal of any such materials.

(14) All machinery and other equipment, associated with the Home Based Business must, at all times, be located within a completely enclosed

accessory building, accessory to the residential dwelling which is on the same parcel as the business.

(15) Outdoor Storage: No visible outdoor storage is permitted.

(a) Motor Vehicles: All vehicles associated with the home based business shall comply with all applicable provisions of Section 154.260 of this Chapter. No more than three (3) vehicles associated with the home based business shall be parked outdoors.

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NOTE: Review and, if necessary, update table of permitted uses.

TOWNSHIP OF SPARTA

ORDINANCE NO. ____

**AN ORDINANCE TO REGULATE CRYPTOCURRENCY DATA MINING FACILITIES
AND DATA CENTERS**

The Township of Sparta ordains:

Section 1. Addition of New Section 154.235 to the Zoning Ordinance.

A new Section 154.235 entitled "Cryptocurrency Data Mining Facilities and Data Centers" is hereby added to the Township's Zoning Ordinance, to read, in its entirety, as follows:

Section 154.235 Cryptocurrency Data Mining Facilities and Data Centers.

A. Definitions.

CRYPTOCURRENCY DATA MINING FACILITY. A facility dedicated to operating data processing equipment for commercial cryptocurrency mining and the process by which cryptocurrency transactions are verified and added to digital ledgers.

DATA CENTER. A structure that houses information technology infrastructure and equipment for building, running, and delivering applications, and the storage of digital data. This includes Artificial Intelligence ("AI") Data Centers.

B. General Provisions.

- (1) Cryptocurrency Data Mining Facilities and Data Centers are permitted in the Township only as a special land use in the Industrial Zoning District.
- (2) The Township may enforce any remedy or enforcement, including but not limited to, the removal of any Cryptocurrency Data Mining Facilities and Data Centers pursuant to the Zoning Ordinance or as otherwise authorized by law if the Cryptocurrency Data Mining Facility or Data Center does not comply with this Section.

C. Special Land Use Application Requirements. In addition to the requirements of Section 154.186 an applicant for special land use approval of a Cryptocurrency Data Mining Facility or Data Center must provide the Township with all of the following:

- (1) An application fee in an amount set by resolution of the Township Board.
- (2) A list of all parcel numbers that the Cryptocurrency Data Mining Facility or Data Center will use; documentation establishing ownership of each parcel; and any lease agreements, easements, or purchase agreements, for the subject parcels.

- (3) An operations agreement setting forth the parameters of the operation, the name and contact information of the operator, the applicant's inspection protocol, emergency procedures, and general safety documentation.
- (4) Current photographs of the subject property.
- (5) A site plan that includes all proposed structures and the location of all equipment, as well as all setbacks, the location of property lines, signage, fences, greenbelts and screening, drain tiles, easements, floodplains, bodies of water, proposed access routes, and road right of ways. The site plan must be drawn to scale and must indicate how the Cryptocurrency Data Mining Facility or Data Center will be connected to the power grid.
- (6) A written plan for maintaining the subject property, including a plan for maintaining and inspecting drain tiles and addressing stormwater management, which is subject to the Township's review and approval.
- (7) A decommissioning and land reclamation plan describing the actions to be taken following the abandonment or discontinuation of the Cryptocurrency Data Mining Facility or Data Center, including evidence of proposed commitments with property owners to ensure proper final reclamation, repairs to roads, and other steps necessary to fully remove the Cryptocurrency Data Mining Facility or Data Center and restore the subject parcels, which is subject to the Township's review and approval.
- (8) A deposit for an escrow account in an amount set by resolution or fee schedule approved by the Township Board. The escrow account is used to cover all costs and expenses associated with the special land use review and/or approval process, which costs can include, but are not limited to, review fees of the Township Attorney, Township Planner, and Township Engineer, as well as any reports or studies which the Township anticipates will be required during the review and/or approval process for the application. At any point during the review process, the Township may require that the applicant place additional monies into escrow with the Township if the existing escrowed funds on account with the Township will be insufficient, in the determination of the Township, to cover any remaining costs or expenses with the review and/or approval process. If additional funds are required by the Township to be placed in escrow and the applicant refuses to do so within 14 days after receiving notice, the Township will cease the zoning review and/or approval process until and unless the applicant makes the required escrow deposit. Any escrow amounts in excess of actual cost will be returned to the applicant. An itemized billing of all expenses will be provided to the applicant upon request.
- (9) A plan for resolving complaints from the public or other property owners concerning the construction and operation of the Cryptocurrency Data Mining Facility or Data Center, which is subject to the Township's review and approval.

- (10) A plan for managing any hazardous waste, which is subject to the Township's review and approval.
- (11) A fire protection plan, which identifies the fire risks associated with the Cryptocurrency Data Mining Facility or Data Center; describes the fire suppression system that will be implemented; describes what measures will be used to reduce the risk of fires re-igniting (i.e., implementing a "fire watch"); identifies the water sources that will be available for the local fire department to protect adjacent properties; identifies a system for continuous monitoring, early detection sensors, and appropriate venting; and explains all other measures that will be implemented to prevent, detect, control, and suppress fires and explosions.
- (12) A transportation plan for construction and operation phases, including any applicable agreements with the County Road Commission and Michigan Department of Transportation, which is subject to the Township's review and approval.
- (13) An attestation that the applicant will indemnify and hold the Township harmless from any costs or liability arising from the approval, installation, construction, maintenance, use, repair, or removal of the Cryptocurrency Data Mining Facility or Data Center, which is subject to the Township's review and approval.
- (14) Proof of environmental compliance, including compliance with Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act; (MCL 324.3101 et. seq.; Part 91, Soil Erosion and Sedimentation Control (MCL 324.9101 et. seq.) and any corresponding County ordinances; Part 301, Inland Lakes and Streams, (MCL 324.30101 et. seq.); Part 303, Wetlands (MCL 324.30301 et. seq.); Part 365, Endangered Species Protection (MCL 324.36501 et. seq.); and any other applicable laws and rules in force at the time the Township considers the application.
- (15) Any additional information or documentation requested by the Planning Commission, Township Board, or other Township representative.

D. System and Location Requirements. In addition to the requirements of Section 154.170 for a site plan, the site plan must include all of the following:

- (1) Equipment. All equipment used in any Cryptocurrency Data Mining Facility or Data Center must be housed in a metered, electrically grounded, and pre-engineered or prefabricated metal-encased structure with a fire rating designed to resist an internal electrical fire for at least 30 minutes.
- (2) Structures. All principal and accessory structures used for cryptocurrency mining operations and/or data centers, shall be arranged, designed, and constructed to be harmonious and compatible with the site and with the surrounding properties. If prefabricated, pre-engineered, or modular structures are installed, the following standards are required:

- a) All structures shall have concrete foundations.
 - b) All exterior facades shall have muted earth tone colors that will blend the facility into the natural setting and existing environment, and shall not be defective, decayed or corroded.
 - c) If intermodal shipping containers are utilized such installation shall comply with current National Electrical Code standards.
- (3) Lighting. The lighting of the Cryptocurrency Data Mining Facility or Data Center is limited to the minimum light necessary for safe operation. Illumination from any lighting must not extend beyond the perimeter of the lot(s) used for the Cryptocurrency Data Mining Facility or Data Center. The Cryptocurrency Data Mining Facility or Data Center must not produce any glare that is visible to neighboring lots or persons traveling on public or private roads.
- (4) Security Fencing. Security fencing must be installed around all electrical equipment related to the Cryptocurrency Data Mining Facility or Data Center. Such fencing must be a minimum seven (7) feet tall and must use materials, colors, textures, screening and landscaping, that will blend the facility into the natural setting and existing environment.
- (5) Noise. The noise generated by the Cryptocurrency Data Mining Facility or Data Center must not exceed 45 dBA Lmax, as measured at the property line of any adjacent parcel.
- (6) Signage. The Cryptocurrency Data Mining Facility or Data Center shall provide a 24-hour emergency contact signage visible at the access entrance. Signs shall include company name if applicable, owner/representative name, telephone number, and corresponding local power company and telephone number.
- (7) Underground Transmission. All power transmission or other lines, wires, or conduits from a Cryptocurrency Data Mining Facility or Data Center to any building or other structure must be located underground at a depth that complies with current National Electrical Code standards, except for power switchyards or the area within a substation.
- (8) Drain Tile Inspections. The Cryptocurrency Data Mining Facility or Data Center must be maintained in working condition at all times while in operation. The applicant or operator must inspect all drain tiles at least once every three years using a robotic camera, with the first inspection occurring before the Cryptocurrency Data Mining Facility or Data Center is in operation. The applicant or operator must submit proof of the inspection to the Township. The owner or operator must repair any damage or failure of the drain tile within sixty (60) days after discovery and submit proof of the repair to the Township. The Township is entitled, but not required, to have a representative present at each inspection or to conduct an independent inspection.

(9) Fire Protection.

- a) Before any construction of the Cryptocurrency Data Mining Facility or Data Center begins, the Township's fire department (or the fire department with which the Township contracts for fire service) will review the fire protection plan submitted with the application. The fire chief will determine whether the fire protection plan adequately protects the Township's residents and property and whether there is sufficient water supply to comply with the fire protection plan and to respond to fire or explosion incidents. If the fire chief determines that the plan is adequate, then the fire chief will notify the Township or his or her designee of that determination. If the fire chief determines that the plan is inadequate, then the fire chief may propose modifications to the plan, which the applicant or operator of the Cryptocurrency Data Mining Facility or Data Center must implement. The fire chief's decision may be appealed to the Township Board, and the Township Board will hear the appeal at an open meeting. The Township Board may affirm, reverse, or modify the fire chief's determination. The Township Board's decision is final, subject to any appellate rights available under applicable law.
 - b) The applicant or operator may amend the fire protection plan from time-to-time in light of changing technology or other factors. Any proposed amendment must be submitted to the fire department for review and approval under subsection (a).
 - c) The Cryptocurrency Data Mining Facility or Data Center must comply with the fire protection plan as approved by the fire chief (or as approved by the Township Board in the event of an appeal).
 - d) The Cryptocurrency Data Mining Facility or Data Center must contain an internal fire suppression system that shall be reviewed and tested once every twelve (12) months by a third-party contractor approved by the fire chief.
- (10) Applicant must provide all Township Fire Department contractors with the appropriate equipment and training to address fires in the Cryptocurrency Data Mining Facility or Data Center.
- (11) Insurance. The applicant or operator will maintain property/casualty insurance and general commercial liability insurance in an amount of at least \$5 million per occurrence. The Township shall be listed as an additional insured on the policy at all times.
- (12) Permits. All required county, state, and federal permits must be obtained before the Cryptocurrency Data Mining Facility or Data Center begins operating. A building permit is required for construction of a Cryptocurrency Data Mining

Facility or Data Center regardless of whether the applicant or operator is otherwise exempt under state law.

- (13) **Decommissioning.** If a Cryptocurrency Data Mining Facility or Data Center is abandoned or otherwise nonoperational for a period of one year, the property owner or the operator must notify the Township and must remove the system within six (6) months after the date of abandonment. Removal requires receipt of a demolition permit from the Building Official and full restoration of the site to the satisfaction of the Zoning Administrator. The site must be filled and covered with top soil and restored to a state compatible with the surrounding vegetation. The requirements of this subsection also apply to a Cryptocurrency Data Mining Facility or Data Center that is never fully completed or operational if construction has been halted for a period of one (1) year.
- (14) **Financial Security.** To ensure proper decommissioning of a Cryptocurrency Data Mining Facility or Data Center upon abandonment, the applicant must post financial security in the form of a security bond or escrow payment in an amount equal to 125% of the total estimated cost of decommissioning, code enforcement, and reclamation, which cost estimate must be approved by the Township. The operator and the Township will review the amount of the financial security every two (2) years to ensure that the amount remains adequate. This financial security must be posted within fifteen (15) business days after approval of the special use application.
- (15) **Extraordinary Events.** If the Cryptocurrency Data Mining Facility or Data Center experiences a failure, fire, leakage of hazardous materials, personal injury, or other extraordinary or catastrophic event, the applicant or operator must notify the Township within 24 hours.
- (16) **Annual Report.** The applicant or operator must submit a report on or before January 1 of each year that includes all of the following:
 - a) Current proof of insurance;
 - b) Verification of financial security; and
 - c) A summary of all complaints, complaint resolutions, and extraordinary events.
- (17) **Inspections.** The Township may inspect a Cryptocurrency Data Mining Facility or Data Center at any time by providing 24-hour advance notice to the applicant or operator.
- (18) **Transferability.** A conditional land use permit for a Cryptocurrency Data Mining Facility or Data Center is transferable to a new owner. The new owner must register their name and business address with the Township and must comply with this Ordinance and all approvals and conditions issued by the Township.

(19) Remedies. If an applicant or operator fails to comply with this Ordinance, the Township, may pursue any remedy or enforcement, including but not limited to the removal of any Cryptocurrency Data Mining Facility or Data Center pursuant to the Zoning Ordinance or as otherwise authorized by law. Additionally, the Township may pursue any legal or equitable action to abate a violation and recover any and all costs, including the Township's actual attorney fees and costs.

Section 2. Amendment of Section 154.247.

Section 154.247, is hereby amended to add Cryptocurrency Data Mining Facilities and Data Centers to the Table of Use Regulations as a special land use in the Industrial zoning district.

Section 3. Validity and Severability.

If any portion of this Ordinance is found invalid for any reason, such holding will not affect the validity of the remaining portions of this Ordinance.

Section 4. Repealer.

All other ordinances inconsistent with the provisions of this Ordinance are hereby repealed to the extent necessary to give this Ordinance full force and effect.

Section 5. Effective Date.

This Ordinance takes effect upon the expiration of 7 days after publication as required by MCL 125.3401(7).

Jamestown Charter Township
Home Occupation Regulations
As of 3/2/2026

Definition

SECTION 2.51 HOME OCCUPATION. A gainful occupation permitted within all detached one family dwellings or within one completely enclosed residential accessory building, which use is clearly incidental and secondary to the use of the dwelling for residential purposes.

SECTION 3.4 HOME OCCUPATIONS. Home occupations are permitted as a special use in any "AR", "R-1", or "R-2" Zoning District, except as otherwise provided herein. All home occupations shall be subject to the following restrictions and regulations:

- A. The home occupation shall be conducted only by persons residing on the premises. Not more than one (1) person shall be employed who is not a resident of the premises.
- B. The home occupation may be conducted either: (i) within the living area or basement of the dwelling itself; or (ii) in an attached garage, or attached or detached accessory building, but not in both (i) and (ii). If conducted within the living area or basement of a dwelling, the home occupation shall occupy a floor area not greater than twenty (20) percent of the gross floor area of the dwelling, or three hundred (300) square feet, whichever is less. If conducted in an attached garage, or attached or detached accessory building, the home occupation shall occupy a floor area not greater than five hundred (500) square feet.
- C. For the purpose of identification of such use in the AR Zoning District, one (1) non-illuminated ground sign erected in accordance with Section 24.12C of this Ordinance may be permitted. For the purpose of identification of such use in the R-1 or R-2 Zoning District, one (1) non-illuminated sign not exceeding two (2) square feet in area may be permitted on a street of thirty-five (35) miles per hour or less. For the purpose of identification of such use in the R-1 or R-2 Zoning District, one (1) non-illuminated sign not exceeding six (6) square feet in area may be permitted on a street of more than thirty-five (35) miles per hour. The location of the sign in the R-1 or R-2 Zoning District may be either flat against the wall of the structure or attached to the mailbox post. A home occupation sign permitted pursuant to this subsection 3.4.C shall identify only the name of the profession and the name of the occupancy of the premises.
- D. No equipment or process shall be used in conjunction with such home occupation, which creates noise, vibration, glare, fumes, light pollution, odors or electrical interference detectable to the normal senses off the lot. All motors and equipment used in the conduct of any home occupation shall be shielded so as not to cause radio or television interference or cause fluctuations in line voltage off the premises.

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E. There shall be no alteration in the residential character of the premises in connection with such home occupation.

F. There shall be no external evidence of the home occupation other than a sign as provided within subsection C above nor more than one (1) piece of merchandise or article for sale shall be displayed for advertising purposes and no sign or device relative to the sale of such merchandise shall be displayed on the premises. Limited retail sales may be permitted on the premises, as a part of or in conjunction with the home occupation and shall not exceed fifty percent (50%) of the gross floor area designated to the home occupation.

G. No equipment, including construction equipment, parts, scrap, finished product, tools, inventory, or any other articles or materials associated with the home occupation shall be stored outdoors. All work and other activities associated with the home occupation shall take place indoors.

H. No more than four (4) vehicles, not including construction equipment, related to the home occupation shall be parked on the property at any one time. All vehicles shall be parked in an approved driveway, parking lot, or area not within the required front yards. No on-street parking is permitted. The intent is to ensure that traffic will not be generated by such home occupation in greater volume than would normally be expected in a residential neighborhood.

I. Home occupations for the medical use of marihuana shall be subject to this Section 3.4I.

1. For purposes of this subsection, the following words and terms shall have the following definitions.

a. General rules: the general rules of the Michigan Department of Community Health, issued in connection with the MMMA.

b. Marihuana: also known as marijuana, also known as cannabis; shall have the meaning given to it in section 7601 of the Michigan Public Health Code, Public Act 368 of 1978, MCL 333.7106, as referred to in section 3(d) of the MMMA, MCL 333.26423(d). Any other term pertaining to marihuana used in this Ordinance and not otherwise defined shall have the meaning given to it in the MMMA or in the general rules.

c. Medical use of marihuana: the acquisition, possession, cultivation, manufacture, use, internal possession, delivery, transfer, or transportation of

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marihuana or paraphernalia relating to the administration of marihuana to treat or alleviate a registered qualifying patient's debilitating medical condition or symptoms associated with the debilitating medical condition, as defined under the MMMA.

d. MMMA: the Michigan Medical Marihuana Act; Public Act 2008, Initiated Law, as amended.

2. Medical marihuana. A registered primary caregiver, in compliance with the general rules, the MMMA, and the requirements of this section, shall be allowed as a home occupation as a matter of right, without obtaining a special use permit, because of the general rules and the confidentiality provisions of the MMMA.

Nothing in this section or in this Ordinance is intended to grant, nor shall this section or this Ordinance be construed as granting, immunity from criminal prosecution for growing, selling, consuming, using, distributing, or possessing marihuana not in strict compliance with the MMMA and the general rules.

Since federal law is not affected by the MMMA or the general rules, nothing in this section or in this Ordinance is intended to grant, nor shall this section or this Ordinance be construed as granting, immunity from criminal prosecution under federal law. The MMMA does not protect users, caregivers or the owners of properties on which the medical use of marihuana is occurring from federal prosecution, or from having their property seized by federal authorities under federal law.

The operations of a primary caregiver are permitted in Jamestown Township only as a home occupation subject to this section. The activities of a primary caregiver or the medical use of marijuana, other than by a qualifying patient for their personal use, does not constitute a commercial, industrial, agricultural or other type of accessory use, and shall not be considered as similar to any listed commercial, agricultural, industrial or other use in the interpretation of this ordinance. Without limiting the generality of the foregoing, facilities at which marijuana is kept for distribution to qualifying patients, other than as permitted herein (sometimes known as "Dispensaries"), locations at which two or more caregivers cultivate marijuana plants (sometimes known as "Common Grow" Facilities) or any other location or facility, except a primary caregiver home occupation, which acquires, possesses, manufactures, delivers, transfers, or transports medical marijuana and sells, supplies or dispenses it to registered qualifying patients, directly or through

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the patient's registered primary caregivers (sometimes known as a "Provisioning Center") shall be prohibited in the Township, whether or not such facilities are now or hereafter permitted under Michigan or federal law.

In addition to the general provisions for home occupations provided by this Section 3.4, the following requirements for a registered primary caregiver shall apply. Where there is inconsistency between the general requirements and the specific requirements, the more stringent requirements shall apply.

- a. The home occupation shall be conducted only in a detached, one family dwelling.
- b. The medical use of marihuana shall comply at all times and in all circumstances with the MMMA and the general rules, as they may be amended from time to time
- c. A registered primary caregiver must be located outside of a one thousand (1,000) foot radius from any school, including any day care facility, to ensure community compliance with federal "Drug-Free School Zone" requirements.
- d. Not more than one registered primary caregiver shall be permitted to service qualifying patients from a dwelling unit.
- e. All necessary building, electrical, plumbing and mechanical permits shall be obtained for any portion of the dwelling unit in which electrical wiring, lighting or watering devices that support the cultivation, growing or harvesting of marihuana are located.
- f. If a room with windows is utilized as a growing location for marihuana, any lighting between the hours of 9:00 PM to 7:00 AM shall employ shielding methods, without alteration to the exterior of the dwelling unit, to prevent ambient light spillage that may create a distraction for adjacent properties.
- g. That portion of the dwelling unit where energy usage and heat exceeds typical residential use, such as a grow room, and the storage of any chemicals such as herbicides, pesticides, and fertilizers shall be subject to inspection and approval by the fire department to ensure compliance with applicable standards.
- h. Registered primary caregivers shall deliver the allowed amount of marihuana to their qualifying patients, so that the transfers of marihuana from registered

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primary caregiver to qualifying patients shall not occur at the dwelling unit where the medical marihuana home occupation is conducted.

i. The lot shall be open for inspection upon request by the building inspector, zoning administrator, fire department and law enforcement officials for compliance with all applicable laws and rules during the stated hours of operation/use and at such other times as anyone is present on the lot.

j. No sign shall be permitted for the medical use of marihuana.

k. Registered primary caregivers shall annually provide evidence of an active State of Michigan registry identification card or be subject to revocation of the home occupation.

J. Home occupations for the instruction in a craft or fine art shall be allowed as a matter of right, without obtaining a special use permit, subject to this Section 3.4.

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Definitions – Section 207

Home Based Business

This is similar to a Home Occupation but can be conducted both in a single-family residential dwelling and an accessory building if approved as a special land use by the Planning Commission. Home Based Businesses include, but are not necessarily limited to, electrical, plumbing, heating, landscaping, and building contractors and excavators.

Home Occupation

An occupation, profession, or service that is clearly a customary, incidental, and secondary or accessory use of a single-family residential dwelling and that does not negatively impact the single family residential character of the neighborhood in which the Home Occupation is located and also meets all of the Home Occupation requirements of this Ordinance.

Section 345-Home Occupations and Home Based Businesses

A. Home Occupations. Home Occupations occur entirely within a single-family residential dwelling and include such businesses and vocations as hair salons, millinery, dressmaking, bookkeeping and accounting services, real estate and insurance sales, the giving of instruction in voice or musical instruments, private tutoring, consulting and counseling services, direct sales and distribution, building trades contractors, and computer related work. Home Occupations are allowed within the Low Density Residential, High Density Residential, Lake Residential, and Agricultural zoning districts and are subject to the following requirements:

1. The Home Occupation use shall only be incidental to the primary single-family residential use.
2. No equipment or process shall be used in a Home Occupation that creates noise, vibration, glare, fumes, odors, or electrical interference detectable to the normal senses off of the lot involved. In the case of electrical interference, no equipment or process shall be used that creates visual or audio interference in or with any radio or television receivers off of the lot involved, or causes fluctuations in line voltage off of the lot.
3. In no event shall the use of a dwelling for a Home Occupation alter the single-family residential character of the dwelling or area. No external alterations, additions, or

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changes to the dwelling that will change the residential character of the dwelling structure shall occur.

4. Any need for additional parking generated by the conduct of such Home Occupation must be accommodated in areas off of the public road right-of-way, and in areas other than the required front yard.

5. The Home Occupation is permitted to operate within a single family dwelling and shall utilize no other floor or area than the main floor of the dwelling and shall utilize no more than fifteen (15) percent of the main floor area of the dwelling, or one hundred twenty (120) square feet, whichever is less.

6. No merchandise or articles for sale shall be displayed outdoors on the lot utilized for the Home Occupation.

7. The allowance of Home Occupations, as provided herein, is intended to secure flexibility in the application of the requirements of this Ordinance; but such permission is not intended to allow the essential character of residential districts and areas, in terms of use and appearance, to be changed by the occurrence of Home Occupations.

8. Only goods produced as part of the Home Occupation, or goods clearly incidental to the operation of the Home Occupation, may be sold on the lot, and the goods shall not be visibly on display outside or on any sign or other device advertising such goods for sale.

9. Signage: In all zone districts one (1) single non-illuminated name plate sign, not exceeding two (2) square feet in area and attached to the principal structure, shall be permitted.

10. The Home Occupation shall involve only members of the immediate family who reside on the lot plus not more than one (1) non-resident.

11. All activities shall be carried on indoors. No accessory building or structure shall be used for the Home Occupation use. No outdoor activities or storage shall be permitted.

12. Similar, but not listed, Home Occupations may be approved by the Zoning Administrator or, at the discretion of the Zoning Administrator, by the Planning Commission at a public meeting, but only after finding that the requested Home Occupation is sufficiently similar to a listed Home Occupation use and after consideration and findings based upon the following standards:

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- (a) Whether the Home Occupation is incidental and secondary to the use of the premises as a single-family residential dwelling.
- (b) Whether the nature of the Home Occupation is substantially in keeping with the single family residential use of the property and neighborhood.
- (c) Whether the likely effects of the Home Occupation upon adjacent and nearby lands would be within the scope of the effects likely to result from other, similar Home Occupations that are specifically permitted.
- (d) Whether the Home Occupation could have measurable adverse effects upon adjacent and nearby lands and the uses thereof permitted.
- (e) Whether the Home Occupation, in all aspects, complies with items 1-12 above.

B. Home Based Businesses. Home Based Businesses are similar to Home Occupations, but can occur both within the single-family residential dwelling and not more than one accessory building located on the same lot as the single-family residential dwelling if approved as a special land use. Home Based Businesses include electrical, plumbing, heating, landscaping, building contractors, and excavators. Home Based Businesses are allowed within the Low Density Residential, High Density Residential, Lake Residential and Agricultural zoning districts if approved as a Special Land Use by the Planning Commission. In addition, all of the following requirements must be met:

1. Home Based Businesses must meet all of the requirements for a Home Occupation specified in Sections A.1 through A.2.
2. The minimum lot area shall be at least two (2) acres in the Agricultural and Low Density Residential zoning districts and fifteen thousand (15,000) square feet in the High Density and Lake Residential zoning districts.
3. In all zone districts a single non-illuminated free-standing identification sign, not to exceed ten (10) square feet in area, a maximum of three (3) feet high and located outside of any public road right-of-way shall be permitted. Such signs are limited to the lot on which the Home Based Business is located.
4. The Home Based Business shall only be incidental to the primary single-family residential use.
5. The Home Based Business shall employ only members of the immediate family residing on the lot and not more than one (1) other person. A second non-resident employee may be approved if sufficient evidence can be provided to the Planning

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Commission (and is part of the submittal for special land use approval) that demonstrates that for purposes of human safety, to maintain the livelihood of the business that otherwise could not be maintained without the second person, or to fill a void in business operations caused by a departure of an employee, the additional employee is necessary.

6. No toxic or hazardous materials may be used or stored on the premises to support such Home Based Business except in a safe manner and in full compliance with federal, state, and local requirements as to use, handling, storage, transport, and disposal of any such materials.

7. The applicant shall include, in the submittal for the special land use, an exit plan to illustrate the steps to be executed to cease operation of the Home Based Business use. The exit plan shall include the removal of signage, removal of outdoor storage of supplies and materials, removal and restoration of special driveways and parking areas, removal of any exterior lighting, exterior overhead wiring or wireless communication equipment previously installed for the Home Based Business.

8. All structures used for such Home Based Businesses shall be set back a minimum distance as required by the zone district for the principal uses or accessory uses as applicable.

9. All machinery and other equipment, associated with the Home Based Business must, at all times, be located within a completely enclosed accessory building, accessory to the residential dwelling which is on the same parcel as the business. If outdoor storage of supplies and materials is permitted as part of the Special Use request all such storage of supplies and materials must be screened with a greenbelt landscaping consisting of two staggered rows of evergreen trees planted ten (10) feet on center and a minimum of six (6) feet high at the time of planting. Such landscaping shall be shown in detail on the site plan submittal as required in Zoning Ordinance Section 1901-A.

C. Existing Home Based Businesses. Any Home Based Business that existed within the Township as of October 6, 2012 shall be deemed to be a lawful nonconforming use and shall be allowed to continue at the same scope (without having to obtain a special land use approval), but only if the Home Based Business fully complies with the requirements of Sections B.1 through B.7 above and such compliance occurs on or before October 6, 2012. Any Home Based Business that existed as of October 6, 2012 and which does not fully comply with Sections B.1 through B.7 on or before October 6, 2012, shall not be deemed a

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lawful nonconforming use but rather shall be an unlawful use and shall stop immediately and be abated. Any new Home Based Business, or any expansion or alteration of an existing Home Based Business, after the adoption of this Ordinance, as dated herein, may be allowed only after following the procedures of, and in compliance with, this Ordinance.

SAMPLE

Allendale Charter Township
Home Occupation Regulations
As of 3/2/2026

Definition – Section 32.09

Home Occupation. Any use customarily conducted entirely within a dwelling and carried on by the inhabitants thereof, which use is clearly incidental and secondary the use of the dwelling for residential purposes and does not involve any alteration of the structure or change the character thereof, and which complies with the requirements of Section 23.07.

Section 23.07 HOME OCCUPATIONS

Home Occupations as defined in Section 32.05 are permitted in any residential zone or in the agricultural zone provided that the following conditions are met:

- A. The home occupation shall only be incidental to the primary residential use.
- B. No equipment or process shall be used in such home occupation which creates noise, vibration, glare, fumes, odors, or electrical interference detectable to the normal senses off the lot. In the case of electrical interference, no equipment or process shall be used which creates visual or audio interference in any radio or television receivers off the premises, or causes fluctuations in line voltage off the premises.
- C. The home occupation shall not employ persons other than those members of the family residing on the premises.
- D. The majority of activities shall be carried on indoors. No visible outdoor storage is permitted.
- E. There shall be no change in the exterior appearance of the building or premises, or other visible evidence of the conduct of such home occupation other than one identification sign, not exceeding two (2) square feet in area, non-illuminated and mounted flat against the wall of the principal building.
- F. No traffic shall be generated by such home occupation in greater volumes than would normally be expected in a residential neighborhood, and any need for parking generated by the conduct of such home occupation shall be met off the street and other than in the required front yard.
- G. The permission for home occupations as provided herein is intended to secure flexibility in the application of the requirements of this ordinance; but such permission is not intended to allow the essential residential character of residential districts, in terms of use and appearance, to be changed by the occurrence of non-residential activities.

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H. Limited retail sales may be permitted on the premises, as a part of or in conjunction with a home occupation.

I. Medical Marihuana. A registered primary caregiver, in compliance with the General Rules, the MMMA and the requirements of this Section, shall be allowed as a Home Occupation. Nothing in this Section or in this Ordinance is intended to grant, nor shall this Section or this Ordinance be construed as granting, immunity from criminal prosecution for growing, selling, consuming, using, distributing, or possessing Marihuana not in strict compliance with MMMA and the General Rules. Also, since Federal law is not affected by the MMMA or the General Rules, nothing in this Section or in this Ordinance is intended to grant, nor shall this Section or this Ordinance be construed as granting, immunity from criminal prosecution under Federal law.

The MMMA does not protect uses, caregivers or the owners of properties on which the Medical Use of Marihuana is occurring from Federal prosecution, or from having their property seized by Federal authorities under the Federal Controlled Substances Act or any other applicable Federal legislation. The following requirements for a registered primary caregiver shall apply.

1. The Medical Use of Marihuana shall comply at all times and in all circumstances with the MMMA and General Rules, as they may be amended from time to time.
2. A registered primary caregiver must be located outside of a one thousand (1,000) foot radius from any school, including any Day Car Home, to insure community compliance with Federal "Drug Free School Zone" requirements.
3. Not more than one (1) registered primary caregiver shall be permitted to service qualifying patients from a Dwelling Unit.
4. All necessary building, electrical, plumbing and mechanical permits shall be obtained for any portion of Dwelling Unit in which electrical wiring, lighting or watering that support the cultivation, growing or harvesting of Marihuana are located.
5. If a room with windows is utilized as a growing location for Marihuana, any lighting between the hours of 11:00 p.m. to 7:00 a.m. shall employ shielding methods, without alteration to the exterior of the Dwelling Unit, to prevent ambient light spillage that may create a distraction for adjacent properties.
6. That portion of the Dwelling Unit where energy usage and heat exceeds typical residential use, such as a grow room, and the storage of any chemical such as

Allendale Charter Township
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herbicides, pesticides, and fertilizers shall be subject to inspection and approval by the Fire Department to insure compliance with applicable standards.

7. The Lot shall be open for inspection upon request by the Zoning Administrator, the Fire Department and law enforcement officials for compliance with all applicable laws and rules during the stated hours of operation/use and at such other times as anyone is present on the Lot.

8. The permitted Sign for the Medical Use of Marihuana shall not include a pictorial representation, of the product provided at that Dwelling Unit, nor any references to Marihuana, alternate spellings of Marijuana or slang terms of Marihuana, nor any references to or pictorial representations of drug paraphernalia (as defined in Township Ordinance No. 434, as amended or restated from time to time).

J. Any person who wishes to operate a home occupation as defined herein, which can and will consistently meet the standards for operation contained in this article shall be issued a home occupation permit by the zoning administrator. All necessary licenses and clearances required by state and local agencies must be obtained prior to initiating the proposed home occupation. Each applicant for a home occupation permit shall sign a statement in the application agreeing to the above conditions.

K. Any person who wishes to operate a home occupation which meets the intent of this section, but would not comply strictly with the above standards, may apply for approval as a special use. Permission to operate such a home occupation may be authorized by the Planning Commission upon finding that the intent of this section is upheld and that the proposed use complies with the standards for approval of special use permits (Section 20.06)

