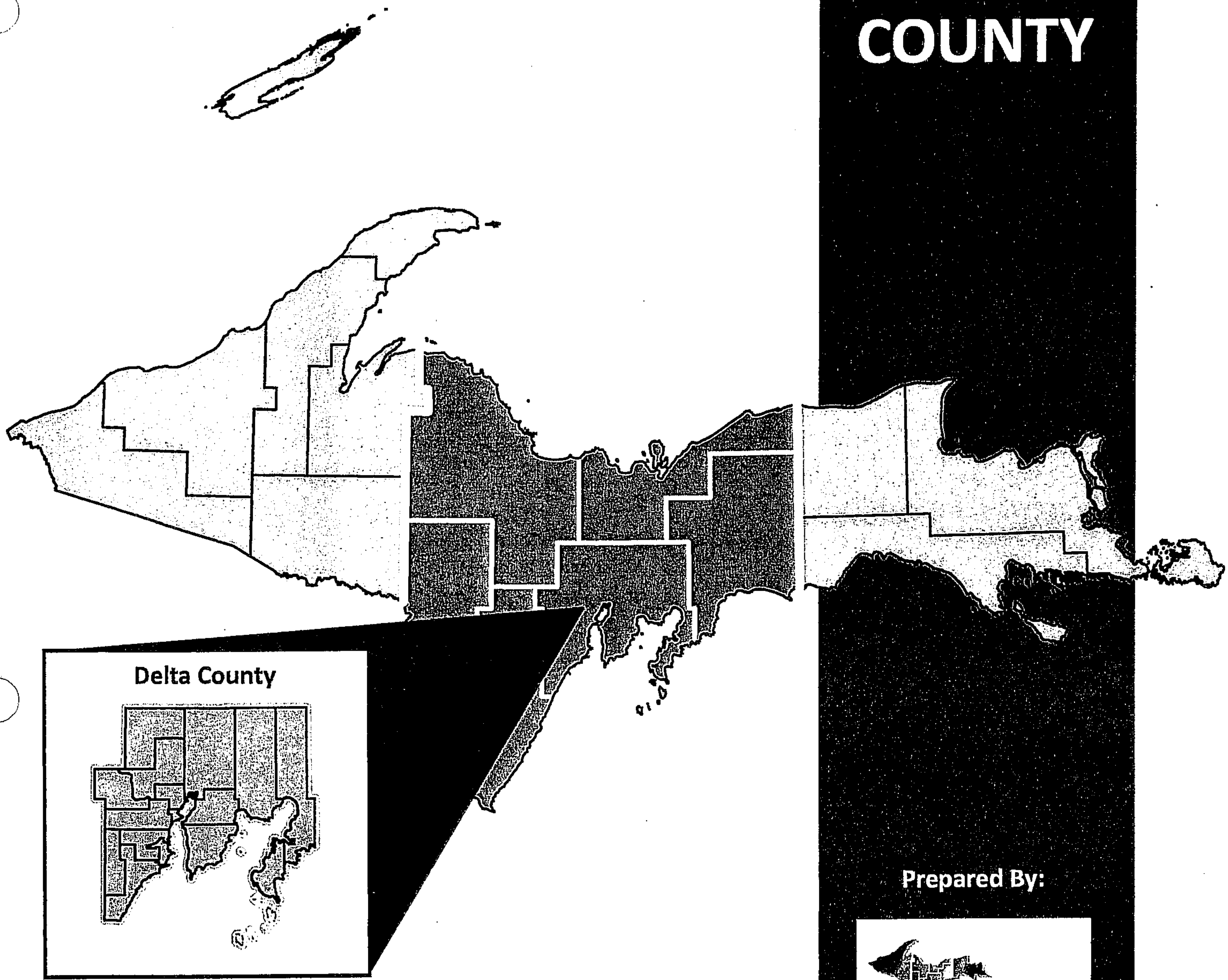
DELTA COUNTY



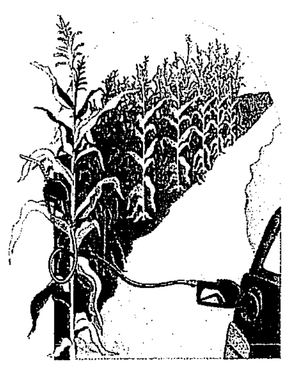
Prepared By:

CUPPAD

Central Upper Peninsula Planning And Development Regional Commission

ENERGY ASSESSMENT

July 2009



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Delta County Energy Assessment Study

Executive Summary

Currently, Delta County has the following resources:

Biomass
Forests: 748,800 acres

Non Forest: *Biomass*

Farm Biomass: 74,272 acres identified as farms; average farm is 272 acres
Percent of farm land harvested cropland: 35.79% (26571 acres)
All wheat for grain: 604 harvested acres
Vegetables: 379 harvested acres
Land in orchards: 72 acres
Corn for grain: 2110 harvested acres

Cattle:	7,979 head	73,000 tons of waste/yr	18,000,000 gallons of waste/yr
Poultry:	874 head	39 tons of waste/yr	9,400 gallons of waste/yr
Hogs:	230 head	440 tons of waste/yr	110,000 gallons of waste/yr
Sheep:	37 head	15 tons of waste/yr	3,600 gallons of waste/yr

Wind
Sustained wind required for commercial uses: 14 mph
Sustained inland wind speeds where documented: Bark River, 8 to 12 mph
Sustained lake wind speeds: 15.7 to 19.7 mph.

Geo-thermal
Geo-thermal energy production capability: None
Geothermal surface heating/cooling potential: 55 degrees Fahrenheit

Hydro-electric Power
Escanaba River Dam #1: 1.95 MW (megawatts of power)
Escanaba River Dam #3: 2.5 MW
Escanaba River Dam #4: (Boney Falls): 4.74 MW

Solar:
Average days of sun: 186

Waste-to-energy:
2008 household garbage (type II waste): 81,607 cubic yards

Tires
2007 production: 3,441 tires
2008 production: 2,395 tires

Current amount of tires burned in New Page facility: 90 tons per day (co-burned with wood waste and coal)
Source of tires burned in New Page facility: Wisconsin and Baraga County, MI

Methane production:
Cost-effective recovery using current technology: 150 to 175 cubic feet per minute
Delta County Solid Waste Authority Landfill production: 80 to 90 cubic feet per hour
Anticipated production at capping of Landfill (approximately 2012): 150 to 175 cubic feet per hour

Escanaba Waste Water Treatment Plant production: 25,000 cubic feet per day
(Currently this methane is used to heat the Wastewater Treatment Plant, and to maintain the optimum temperature for the bacteria in the digesters to function at their highest efficiency. During the summer the methane is burned off.)

Status of Alternative Energy in Delta County

Delta County is just beginning to take advantage of the opportunities and resources it has for energy production. Biomass, both forest and non-forest material, has substantial potential for energy production. Several oil crops, notably canola and camelina, which are not grown in any measurable quantities, appear to have potential and experimented with in the U.P. Fresh water algae has potential, as Delta County has abundant fresh water and algae is noted for its ability to produce oils, but current technology does not make fresh water algae cost-effective in the Michigan climate. Switchgrass in pelleted form is currently being experimented with as an adjunct to forest wood slash and stover.

Wind is abundant on the lakes. However, sustained wind is less than necessary for a viable utility source inland, with the possible exception of localized, single property uses, such as a hunting camp or farm.

Geothermal energy is limited to surface heat suitable for heating and cooling of residential and business structures, but Delta County has no hot springs or similar resources to make geothermal energy a viable source of electrical or mechanical energy within the county.

Overall, the field of alternative energy is in its infancy. New technologies are being developed almost on a daily basis and older technologies are being modified for greater affiance. Brewing used yeast to produce alcohol thousands of years ago is an excellent example of this. Today, technology is using a variety of biologic techniques to produce alcohol for vehicles at a rate the old time brewers would have never thought possible.

Economic Development Potential

Alternative energy has two components when viewed in terms of economic development. The first is usable energy, which is renewable, sustainable, and has a low environmental footprint. As fossil fuels become used up, the price of the fossil fuels can be expected to increase. This in turn increases the cost of all other economic factors. Fossil fuels have been blamed for a variety of environmental problems as well, including the greenhouse effect blamed on waste CO_2, global warming, pollution, fuel spills, and a host of other negative environmental issues. The ideal energy source costs little or nothing, is sustainable, has no environmental hazards, and is readily available in large quantities.

The other economic impact comes from the production of energy from alternative resources. Most, if not all, alternative energy requires specialized technology and equipment. This in turn means manufacturing, maintenance, design, installation, construction and similar labor intensive activities. The net result is job creation. There is no valid reason why some of the employment opportunities created by the production of alternative energy cannot be located in Delta County, Michigan.

Introduction

Delta County is located in the south central Upper Peninsula of Michigan. When originally surveyed in 1843, Delta County not only included its present area but also Menominee and parts of Dickinson, Iron and Marquette Counties. Today the county has a total area of 1,992 square miles (5,158 km²), of which 1,170 square miles (3,030 km²) is land and 822 square miles (2,128 km² or 41.25%) is water. Delta County has 211 miles of shoreline on Lake Michigan. There are 765,495 acres of forest land, including both private and National Forest area.

Delta County, like the rest of the world, is just beginning to see the benefits, challenges, and impacts of a continually evolving field. Just as the beast of burden replaced some forms of manual labor, and first steam and later the internal combustion engine replaced the beast of burden for many types of work, new alternative energy sources and uses of will impact our lives in the future. New forms of energy will create new types of jobs, more efficient uses of existing energy, and new technologies.

When one considers any energy source, be it wind, solar, bio-fuel, geothermal, or some other energy source, there will always be costs in one form or another. These costs may be in the form of monetary costs, environmental costs, aesthetic costs, or a combination of these. As an example, windmills have been used in Holland since at least the tenth century. These windmills were/are viewed as “quaint’ and as an aesthetic part of the landscape. One of the arguments used by windmill opponents is the aesthetics. This same argument is used by windmill proponents. As the saying goes, “Beauty is in the eye of the beholder.” This study makes no attempt to address biases, pro or con, beyond acknowledging that biases do exist. Monetary and environmental costs may be addressed with the understanding that advances in technology may make an energy source less costly or more costly as technology develops.

Alternative energy has two components when viewed in terms of economic development. The first is usable energy production, which is renewable, sustainable, and has a low environmental footprint. As fossil fuels become used up, the price of the fossil fuels can be expected to increase. This in turn increases the cost of all other economic factors. Fossil fuels have been blamed for a variety of environmental problems as well, including the greenhouse effect (blamed on waste CO_2), global warming, pollution, fuel spills, and a host of other negative environmental issues. The ideal energy source costs little or nothing, is sustainable, has no environmental hazards, and is readily available in large quantities.

The other economic impact comes from the production of energy from alternative resources. Most, if not all, alternative energy requires specialized technology and equipment. This in turn means manufacturing, maintenance, design, installation, construction and similar labor-intensive activities. The net result is job creation. There is no valid reason why some of the employment opportunities created by the production of alternative energy cannot be located in Delta County, Michigan. The installation and utilization of alternative energy technology—be it wind power, solar power, heat capture, bio-fuels, geothermal ground heat, waste-to-energy or any of the other technologies—require skilled personnel.

On June 16, 2009, The Energy and Natural Resources Committee approved an energy bill by a 15-8 bipartisan vote. But both Democrats and Republicans expressed concerns about the bill and hope to make major changes when it reaches the Senate floor, probably in the fall. The measure's primary thrust is to expand the use of renewable sources of energy such as wind, solar and geothermal sources as well as deal with growing worries about the inadequacies of the nation's high-voltage power grid. The reconstruction/upgrade of the nation’s high-voltage power grid, while not limited to the Upper Peninsula, would create a number of jobs upgrading and maintaining the power system. Similar jobs would come from the production of bio-mass for power generation by growing crops such as willow and oil seed, which have the potential of advancing energy related agriculture in the U.P.

Chapter 1. Wind

For utility-scale turbines, Class 3 wind and above is needed (above 11 mph). Michigan has very good Class 3 and some Class 4 winds but most of the inland portions of Delta County do not have adequate sustained wind for energy utility purposes. Those with much larger land parcels in areas where the wind blows at least 14 mph might have the option to lease land to a wind developer. Sustainable winds of at least 14 miles per hour are found primarily at elevations of 70-plus meters (200-plus feet) above the surface of the ground, making most wind towers using current technology impractical unless developed on a significantly larger scale.

The U.S. Department of Energy Wind Power maps at 50 meters indicate that at 50 meters (164 feet), with some exceptions along the lake shore, wind power is probably not a good choice for a wind utility. Anemometer studies near Bark River showed an average wind speed of 10.33 mph at 100 feet over the course of a year, with winter readings being the highest at over 12 mph and summer readings being the lowest with averages in the 8 to 9 mph range. Overall, the inland areas received marginal to poor ratings for wind power generation. As wind technology continues to improve, single-user wind power generation may be feasible at some inland locations.

The same maps showed that winds near the lakeshore, where there is a substantial area without obstructions, had winds ranging from good (averaging 15.7 to 16.5 mph) to outstanding (averaging 17.9 to 19.7 mph). Aesthetics and other issues aside, from strictly a wind speed standpoint, there is some potential for developing a wind utility in certain shallow water areas of Lake Michigan.

JoAnne Blank, Senior Project Manager of AECOM, pointed out that in addition to high sustained wind velocities, wind farms require large amounts of land. While the footprint of a single tower is relatively small, the optimum placement of such towers needs approximately forty acres of land per tower to accommodate setbacks, tower development and other related construction, maintenance and operation requirements.

Landowners with at least a one-acre parcel and average sustained winds of 10 mph winds might consider a small wind turbine to **offset** energy costs. Homes use approximately 9,400 kilowatt-hours (kWh) of electricity per year (about 780 kWh per month). Depending upon the average wind speed in the area, a wind turbine rated in the range of 5 to 15 kilowatts would be required to make a significant contribution to meet this demand. While it is unlikely that a residential wind turbine will produce enough power to sell back to the power companies, in all but the most extreme cases, turbines can significantly reduce home electric bills where there is sufficient sustainable wind.

Studies are being proposed to examine the viability of developing low-velocity wind power technology by Michigan State University. If these studies prove that low-velocity wind power is cost-effective, the wind speeds of 8 to 10 mph might be a limiting factor in using wind power in Delta County.

The cost of small wind turbines is steadily decreasing. As one would expect, the larger the wind turbine, the higher the cost will be. However, a system that will allow a single home to go off-grid may be purchased anywhere from less than $5,000 to almost $50,000, depending on the model, capability, design and installation.

Chapter 2. Solar

On average, there are 186 sunny days per year in Delta County (measured at Wells Township). The July high is around 78 degrees Fahrenheit. The January low is 7. The comfort index, which is based on humidity during the hot months, is a 62 out of 100, where higher is more comfortable. The U.S. average on the comfort index is 44.

Solar energy is the radiant light and heat from the sun that has been harnessed by humans since ancient times. People "worshipped" the sun 5,000 years ago. Ra, the sun-god, was considered the first king of Egypt. The sun-god Mesopotamian, Shamash was a major deity and was equated with justice. Ancient Greece had two sun deities, Apollo and Helios. The sun appears in other religions as well: Zoroastrianism, Mithraism, Hinduism, Buddhism, Roman religions, the Druids of England, the Aztecs of Mexico, the Incas of Peru, and many Native American tribes all are influenced by the sun.

Solar radiation, along with secondary solar resources (such as wind and wave power) and biomass account for most of the available renewable energy on Earth. Only a minuscule fraction of the available solar energy is used.

Depending on the way they capture, convert and distribute sunlight, solar technologies are broadly characterized as either passive solar or active solar. Active solar techniques include the use of solar thermal collectors, photovoltaic panels with electrical or mechanical equipment, to capture and convert sunlight into a useful power resource. Passive solar techniques include orienting a building to the sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. There are several types of solar technologies that are currently in use and that may be cost-effective in Delta County. A few examples of the technologies currently available in Delta County are:

Photovoltaic Cells and Inverters: A photovoltaic cell is synonymous with a solar cell. When sunlight strikes the cell, it is converted into an electric current. To be used, a photovoltaic inverter changes the electricity from direct current to alternating current.

Solar Batteries: A solar battery discharges solar energy to an electronic device through an inverter. Solar batteries are reusable and reduce landfill waste. Solar batteries come in various sizes depending on the amount of power that needs to be released. Consumers can use a solar battery to power small devices like calculators and computers. Even something as large as a golf cart can be powered with solar batteries.

Solar Heaters: Solar heaters can be purchased or built by competent do-it-yourselfers. Homemade solar heaters often are not extremely attractive, but they are functional.

Solar Ovens: Solar ovens are simple and cheap to build, making them excellent alternatives for fuel-deprived third world countries. Solar cookers have been made using such diverse materials as reflective automobile sunshades, pizza boxes, foil-lined umbrellas, Fresnel lenses, and tin cans. Solar ovens are used world-wide for cooking and water pasteurization, as well as certain industrial uses like drying fruits and vegetables, candle making, and killing insects and vermin in grains. In Delta County, a solar oven is more likely to be built as a curiosity or a toy than for any other purpose, but that does not negate the fact that the solar oven is capable of being used as a viable energy alternative.

Solar Lighting: Solar lighting equipment can be purchased that will power an entire house. It can also be an inexpensive alternative for outside lighting in locations where ambient light will not override the light-sensitive switch that turns the lights on when a sufficient level of darkness is reached. These lights store energy during the day and turn on at night without being hooked up to a larger power source, solar or otherwise.

Contrary to popular belief, solar power is effective in northern climates, as is evidenced by Solar Minnesota, an initiative coordinated by the Minnesota State Energy Office. Solar Minnesota was originally part of the former federal Million Solar Roofs Initiative, established in 1997, which has evolved into the federal government's Solar America Initiative. Solar Minnesota's goal is to encourage and assist Minnesota residents, businesses, and organizations to install 500 solar systems by 2010. The focus is on solar electric systems that produce electricity from sunlight (photovoltaic), and solar thermal systems that produce heat for domestic hot water, space heating and swimming pools.

Solar Utilities: If solar power is to be considered for commercial utility purposes, a solar assessment should be undertaken. Commercial grade solar assessments look at existing power usage to determine if the use of solar power is cost-effective. Commercial grade basements also look at the suitability of the land on which ground-mounted solar panels may be placed. Suitable land requires 5-6 acres/MGW with no trees blocking the sun from the solar collectors and adequate sunlight conditions to be cost-effective. The assessment also examines transmission capability and the structural suitability of potential roof mounted collectors.

Chapter 3. Biomass

At the current time, biomass may be the easiest place to address alternative energy in Delta County. Delta County has substantial forest lands both in government hands and in private ownership which can produce biomass both directly for energy production and as a by-product (waste product) from the harvesting process for the wood and paper industry.

There is an additional agricultural industry in Delta County, which can produce biomass grown specifically for energy or can produce farm waste, which can also be used for the production of energy. Alternative energy production is creating new markets for energy related agricultural products such as oil-seed plants, non-woody combustibles such as switchgrass, and rapid-growth woody growth such as hybrid willow and poplar.

<u>Forest Biomass</u>

Delta County has 748,800 acres in forest land (1170 sq mi, or 79% of the land area). This land is held by various public and private owners:

- US Forest Service: 241,590 acres
- State of Michigan: 45,000 acres
- Plum Creek Industrial Forest (a private owner): 57,314 acres
- Small Farms: 74,242 acres (42,000 in agricultural production; average farm is 272 acres, with the remainder in woodlands or pasture)
- Private non-industrial forest: 240,100 acres
- Hannahville Indian Community: 270 acres

<u>Non-Forest Biomass</u>

Farm Biomass: 74,272 acres identified as farms; average farm is 272 acres
Percent of farm land harvested cropland: 35.79% (26,571 acres)
Non-harvested agricultural land (pasture, wood lots, etc.): approximately 15,429 acres
All wheat for grain: 604 harvested acres
Vegetables: 379 harvested acres
Land in orchards: 72 acres
Corn for grain: 2,110 harvested acres

Cattle:	7,979 head	73,000 tons of waste/yr	18,000,000 gallons of waste/yr
Poultry:	874 head	39 tons of waste/yr:	9,400 gallons of waste/yr
Hogs:	230 head	440 tons of waste/yr	110,000 gallons of waste/yr
Sheep:	37 head	15 tons of waste/yr:	3,600 gallons of waste/yr

Biomass has numerous potentials for development. Several of the vegetable oils from oilseed plants and algae can be blended directly into bio-diesel. Other products can be processed by means such as gasification into various fuels. Gasification is a method for extracting energy from many different types of organic materials. Gasification is a process that converts organic carbonaceous materials, such as coal and petroleum (fossil organic fuels), biofuel, or biomass, into carbon monoxide and hydrogen by reacting the raw material at high temperatures with a controlled amount of oxygen and/or steam. The resulting gas mixture is called synthesis gas or syngas and is itself a fuel.

The advantage of gasification is that using the syngas is potentially more efficient than direct combustion of the original fuel because it can be combusted at higher temperatures or even in fuel cells. Syngas may be converted via the Fischer-Tropsch process into synthetic fuel, used to produce methanol and hydrogen, or burned directly in internal combustion engines. The high-temperature combustion refines out problematic elements such as chloride and potassium, allowing production of clean gas.

Non-Forest Biomass being tested for energy uses:

Certain agricultural products have shown a great deal of promise for biofuel production in other areas. Some of these same products could be used to both promote a new agricultural market for the U.P. and to provide fuel for the future.

Canola

Also known as rape or rapeseed (from the Latin word for turnip), Canola is one of two types of rapeseed. Their seeds are used to produce edible oil that is fit for human consumption because it has lower levels of erucic acid (a mildly toxic compound used in transmission oils, paint thinners and photographic emulsions) than traditional rapeseed oils. Seeds are also used to produce livestock feed because it has reduced levels of the toxin glucosinolates (a natural pesticide and the plants defense against herbivores). The name "canola" was derived from "Canadian oil, low acid" in 1978. A product known as LEAR (for *low erucic acid rapeseed*), derived from cross-breeding of multiple lines of rapeseed, is also referred to as canola oil and is considered safe for consumption.

Experimental planting at Michigan State University's Chatham, Michigan, Experimental Station produced low yields of the crop. Since Canola is raised commercially in Canada, North and South Dakota, and Northwestern Minnesota, further experiments may be warranted in the Upper Peninsula.

Camelina

Camelina sativa, usually known in English as camelina, gold-of-pleasure, or false flax (also occasionally wild flax, linseed dodder, German sesame, and Siberian oilseed) is a flowering plant in the family Brassicaceae, which includes mustard, cabbage, rapeseed, broccoli, cauliflower, kale, and brussel sprouts. It is native to Northern Europe and Central Asian areas, but has been introduced to North America, possibly as a weed in flax.

Camelina has been traditionally cultivated as an oilseed crop to produce vegetable oil and animal feed. There is ample archeological evidence to show it has been grown in Europe for at least 3,000 years. During the Bronze Age and Iron Age, it was an important agricultural crop in northern Greece beyond the current range of the olive. Camelina apparently continued to be grown at the time of the Roman Empire and until the 1940s it was an important oil crop in eastern and central Europe. Camelina has continued to be cultivated in a few parts of Europe for its seed, which was used in oil lamps and as an edible oil.

The crop is now being researched due to its exceptionally high levels (up to 45%) of omega-3 fatty acids, which is uncommon in vegetable sources. Over 50% of the fatty acids in cold-pressed Camelina oil are polyunsaturated. The oil is also very rich in natural antioxidants, such as tocopherols, making this highly stable oil very resistant to oxidation and rancidity. It is well-suited for use as a cooking oil, having an almond-like flavor and aroma. It may become more commonly known and become an important food oil for the future.

Dr. Keith Downey of the Canola Council of Canada, speaking in Saskatoon, Saskatchewan, believes that Camelina is the best of the non-food crops for oil production in Canada's western prairies. Canada and Montana both have harsher climates than the Upper Peninsula. Initial plantings at the Chatham Experimental Station, using seed from Montana, proved disappointing but since the crop is grown in Canada and Montana and therefore should be viable in Upper Michigan, further experimentation may be warranted.

Because of its apparent health benefits and its technical stability, gold-of-pleasure and camelina oil are being added to the growing list of foods considered as functional foods. Gold-of-pleasure is also of interest for its very low requirements for tillage and weed control. This could potentially allow vegetable oil to be produced more cheaply than from traditional oil crops, which would be particularly attractive to biodiesel producers looking for a feedstock cheap enough to allow them to compete with petroleum diesel and gasoline.

Switchgrass

Much of North America, especially the prairies of the Midwest, was once prime habitat to vast swaths of native grasses, including switchgrass, indiangrass, eastern gamagrass, big bluestem, little bluestem, and others. As European settlers began spreading west across the continent, the native grasses were plowed up and the land converted to growing crops such as corn, wheat, and oats. Introduced grasses such as fescue, bluegrass, and orchardgrass also replaced the native grasses for use as hay and pasture for cattle.

Because it is native, switchgrass is resistant to many pests and plant diseases, and it is capable of producing high yields with very low applications of fertilizer. This means that the need for agricultural chemicals to grow switchgrass is relatively low. Switchgrass is also very tolerant of poor soils, flooding and drought.

There are two main types of switchgrass: upland types, which usually grow 5 to 6 feet tall and are adapted to well-drained soils, and low land types, which grow up to 12 feet tall and are typically found on heavy soils in bottomland sites. Although switchgrass is native, plant breeders have developed a fairly large number of improved varieties for use as forage. Switchgrass reaches full yield only in the third year after planting; it produces a quarter to a third of full yield in the first year, and about two thirds of full yield in the second year. When managed for energy production, it can be cut once or twice a year with regular hay or silage equipment.

Switchgrass is not efficient as a source for liquid fuels, with current technology. It is potentially a cost-effective replacement for solid fossil fuel when pelleted and burned directly. Renewable solid fuels could be used instead of non-renewable liquid heating fuels and gas reducing the use of fossil fuels and greenhouse gas emissions. At Resource Efficient Agriculture Production Canada (REAP's) Farm and Research Facility in Ste-Anne-de-Belleville, Quebec, they cut the switchgrass down in November, just before it snows, then harvest it in April after the snow has melted away. The winter dries the plant enough so that it just has to be compressed into fuel pellets. REAP's pellets, which look like green charcoal briquettes, can be used in the same applications as coal or natural gas, according to Samson. They yield seven times as much energy per hectare of land as corn does.

According to Roger Samson, Executive Director of REAP, "The biggest user of energy and the biggest contributor of greenhouse gasses to the environment in this country isn't transportation, it's thermal… Heating our houses and institutions with pellets would reduce fossil fuel use and greenhouse gas emissions in a huge way."

According to a five-year study conducted by researchers at the University of Nebraska-Lincoln, switchgrass grown for biofuel production produced 540% more energy than was needed to grow, harvest and process it.

Algae
Algae fuel, also called algal fuel, algenol, oilgae, algaeoleum or third-generation biofuel, is biofuel from algae.

Oil prices, competing demands between foods and biofuel sources, and the world food crisis have ignited an interest in algaculture (farming algae) for making a wide variety of biofuels including vegetable oil, biodiesel, bioethanol, biogasoline, biomethanol, biobutanol, jet fuel, and other biofuels. Algal fuels do not affect fresh water resources, can be produced using ocean and wastewater, are biodegradable and are relatively harmless to the environment if spilled. Algae cost more per pound yet can yield over 30 times more energy per acre than other biofuel crops. Almost the entire algal organism can use sunlight to produce lipids, or oil. The United States Department of Energy estimates that if algae fuel replaced all the petroleum fuel in the United States, it would require 15,000 square miles, which is less than 1/7th the area of corn harvested in the United States in 2000.

Gallons of Oil per Acre per Year	
Corn	18
Soybeans	48
Safflower	83
Sunflower	102
Rapeseed	127
Oil Palm	635
Micro Algae	5,000 – 15,000

Source: Cultivating Algae for Fuel Production, Thomas F. Riesing, Ph.D.

Biological hydrogen production is done in a bioreactor based on the production of hydrogen by algae. Algae produce hydrogen under certain conditions. In 2000, it was discovered that if *C. reinhardtii* algae are deprived of sulfur they will switch from the production of oxygen, as in normal photosynthesis, to the production of hydrogen. While not at present commercially viable, hydrogen is in itself a potent source of energy.

As of 2008, algal fuels are too expensive to replace other commercially available fuels. Some of the current technological advances include growing algae in clear plastic towers rather than in flat ponds. The towers have the advantage of allowing sunlight to reach the entire algae field, rather than penetrating only a few inches through the algae “mat” of a flat pond surface.

Used as food in many countries, and as a food ingredient in others, algae also has other uses which can relate to energy and environmental issues, such as pollution control. Sewage can be treated with algae, reducing the need for greater amounts of toxic chemicals than are already used. Algae can be used to capture fertilizers in runoff from farms. When subsequently harvested, the enriched algae itself can be used as fertilizer. Algae bioreacters are used by some power plants to reduce CO_2 emissions.

Algae has many factors going for it as a bio-energy source. Whether or not it can be effectively developed in Delta County as an energy source remains to be seen.

The major issue with algae is maintaining photosynthesis. While it is possible to grow algae in pond environments, a few inches of algae minimizes the amount of sunlight reaching the greater depths and photosynthesis is retarded. This can be overcome by the use of transparent tubes mounted in vertical stacks to maximize the amount of sunlight reaching the algae but this is both costly and subject to freezing in Michigan’s northern climate. The cost of creating viable algae stacks currently makes the technology cost-prohibitive, except for experimental purposes.

Miscanthus

Interest in miscanthus as a bio-energy crop is still in its early stages in the United States. Miscanthus is a large perennial grass with potential for use in energy production. It is non-invasive and planted fields are easily reclaimed for corn or soy beans. Miscanthus is high yielding, with yield estimates from 10 to 15 tons per acre. It is considered by the University of Illinois-Urbana campus to be excellent for carbon sequestration and soil building. Miscanthus can be harvested every year with a sugar cane harvester and can be grown in a cool climate like that of northern Europe. Like other bioenergy crops, the harvested stems of miscanthus may be used as fuel for production of heat and electric power, or for conversion to other useful products such as ethanol.

There is little experience with this potential crop in the United States, so its performance under U.S. conditions is unknown, with much of the study being done in Illinois. As with most of the new bioenergy crops, there seems to be a steep "learning curve". Costs are expected to drop and uncertainties to be reduced as first demonstration trials and then commercial plantings become more widespread. In particular, establishment costs appear to be fairly high at present (a wide range is reported from different European countries).

Miscanthus rhizomes have a low tolerance of frost. Care may be required in some locations to minimize frost damage (e.g. by growing a "cover-crop" over the winter, or by spreading a thick layer of straw in the fields). Native species are often preferred in the U.S. However, sterile hybrids have been used for nearly all the European trials, making the escape of non-native plants unlikely.

Like many other alternative energy sources, miscanthus may or may not have a substantial value as a bio-fuel. While the major drawbacks of miscanthus seem to be temperature-related, genetic engineering and technological uses may make it a viable bio-energy source in the U.P. in the future.

Hybrid Willow

Hybrid Willow will, on average, grow six feet per year under normal conditions. Willow is grown for biomass or biofuel in energy forestry systems as a consequence of its high energy in-energy out ratio, fast growth, and large carbon mitigation potential. In the US and the Energy Coppice Project in the UK, large-scale projects to support willow development as an energy crop have been established, such as the Willow Biomass Project. Willow provides a similar amount of energy per ton as other hardwoods, but can be cultivated every few years at relatively low cost. It propagates very easily from cuttings, has a quick growth cycle, and tends to regrow following harvest. Willow can be harvested six to seven times before it needs to be replanted. Willow may also be grown to produce Charcoal.

In Delta County the Traxys Corporation, in cooperation with United BioFuels and Michigan State University, completed its first phase of closed-loop hybrid willow planting on the farm of Barry Bahrman in Skandia, Michigan. Mike Reid, Vice President of the Traxys Energy Group, explained that 180,000 8-inch-long hybrid clones were planted by AA Willow of upstate New York. A special planter designed and imported from Denmark was used to cut and insert the willow clones 6 inches into the soil. Reid explained that the clones will grow about 6 feet this year and by the fourth year grow to over 30 feet tall and 3 inches in diameter; the harvest of wood will be in the range of 30-tons per acre.

Traxys has the first bio-mass power plant in the Upper Peninsula, located in L'Anse, Michigan. That plant presently burns about 300 tons of waste wood a day. Final engineering is being done to convert the Traxys White Pine coal plant and the former steam plant at K.I. Sawyer to biomass. Traxys is also one of the final contenders to purchase the Escanaba power plant if the city goes ahead with a sale of the plant. This plant would also be converted from coal to biomass.

While the conversions are being completed, Traxys will work with local farmers throughout the U.P. to lease land to grow the hybrid willow. "This will be a great opportunity to bring back farming to the U.P.," Reid said. They expect to lease about 60,000 acres to produce enough closed-loop biomass to fuel their plant.

Traxys plans on expanding their present 20-megawatts of biomass to over 100-megawatts in preparation for the Michigan-mandated "Renewable Portfolio Standard" that takes effect in 2012.

Similar experiments are being conducted in other states using specially bred poplar trees as a rapid growth bio-mass. Depending on the outcome of these studies, poplar may also be a viable Delta County agricultural energy product.

Chapter 4. Geo-Thermal

Geothermal energy is heat from within the earth. Steam and hot water produced inside the earth can be used to heat buildings or generate electricity. Geothermal energy is a renewable energy source because the water is replenished by rainfall and the heat is continuously produced inside the earth. Geothermal energy is generated in the earth's core, about 4,000 miles below the surface. Temperatures hotter than the sun's surface are continuously produced inside the earth by the slow decay of radioactive particles, a process that happens in all rocks.

There are three types of geothermal energy use. Two of these are not feasible in Delta County. Direct use and direct heating systems use hot water from springs or reservoirs near the surface. Electricity generation in a power plant requires water or steam at very high temperature (300 to 700 degrees Fahrenheit). Geothermal power plants are generally built where geothermal reservoirs are located within a mile or two of the surface.

Geothermal heat pumps (also known as ground heat or surface heat pumps) use stable ground or water temperatures near the earth's surface to control building temperatures above ground. The use of geothermal heat pumps is feasible in the U.P. and is beginning to be used in Delta County. While temperatures above ground change substantially from day to day and season to season, temperatures in the upper 10 feet of the Earth's surface in most areas hold nearly constant temperatures between 50 and 60 degrees Fahrenheit. For most areas, this means that soil temperatures are usually warmer than the air in winter and cooler than the air in summer. Geothermal heat pumps use the Earth's constant temperatures to heat and cool buildings. They transfer heat from the ground (or water) into buildings in winter and reverse the process in the summer.

According to the U.S. Environmental Protection Agency (EPA), geothermal heat pumps are the most energy-efficient, environmentally clean, and cost-effective systems for temperature control. Geothermal heat requires no fuel, and is therefore virtually emissions-free and insusceptible to fluctuations in fuel cost, with the exception of some electricity to power the pumps. While individual wells may need to recover, geothermal heat is inexhaustible and is replenished from greater depths.

Currently there are several designs of geothermal ground heat pump systems including vertical wells, horizontal fields, and overlapping loop systems. The most effective systems are dependent upon their intended use. Most geothermal systems are not stand-alone systems, but rather are augmented by secondary heating systems that add heat when necessary to maintain a desirable temperature. There is a small amount of secondary energy used, either from fossil fuels or some other source, but the secondary heat needed is minimal compared to the cost of using the same fuel as a primary heating source.

Chapter 5. Waste Products

Every year, tons of waste capable of being used to produce energy is being put into landfills around the nation. A large portion of this material is bio-mass, including paper products, but huge amounts of plastic is also being land-filled. Plastics are basically made of some form of oil, either from petroleum or from agricultural products such as soybean, corn, or similar oils.

Waste-to-energy is the process of creating energy in the form of electricity or heat from the incineration of waste source. Waste-to-energy is a form of energy recovery. Most waste-to-energy processes produce electricity directly through combustion, or produce a combustible fuel commodity, such as methane, methanol, ethanol or synthetic fuels. The most common method of waste-to-energy is incineration, the combustion of organic material such as waste, with energy recovery. Incineration without energy recovery is increasingly being banned worldwide. Modern incinerators have the efficiency to reduce the volume of the original waste by 95-96 %, depending on the degree of recovery of materials such as metals from the ash for recycling and upon the composition of the waste.

There are a number of new and emerging technologies that are able to produce energy from waste and other fuels without direct combustion. A number of these technologies are potentially capable of producing more electric power from the same amount of fuel than would be possible by direct combustion. There are two major categories by which waste-to-energy can be achieved without direct combustion. These are thermal, which uses applied heat but not direct combustion, and non-thermal, which uses mechanical, chemical, or biological methods of producing energy.

Thermal methods:

Gasification: Gasification is a process that converts carbonaceous materials, such as biofuel, or biomass, coal, petroleum, etc., into carbon monoxide and hydrogen by heating the raw material at high temperatures with a controlled amount of oxygen and/or steam. The resulting gas mixture is called synthesis gas or syngas and is itself a fuel. Gasification is a method for extracting energy from many different types of organic materials.

Using the syngas is potentially more efficient than direct combustion of the original fuel because it can be combusted in fuel cells or at higher temperatures or even so that the thermodynamic upper limit to the efficiency is higher. Syngas may be burned directly in internal combustion engines, used to produce methanol and hydrogen, or converted via the Fischer-Tropsch process into synthetic fuel. Gasification can use materials that are not otherwise useful fuels, such as biomass or organic waste. In addition, the high-temperature combustion refines out corrosive elements such as chloride and potassium, allowing clean gas production.

Gasification of fossil fuels is currently used on an industrial scale to generate electricity. Almost any type of organic material can be used as the raw material for gasification, such as wood, biomass, or even plastic waste.

Gasification relies on chemical processes at elevated temperatures greater than 700°C, which distinguishes it from biological processes such as anaerobic digestion that produce biogas. Gasification produces combustible gas, hydrogen, and synthetic fuels.

Thermal Depolymerization: This is a process that mimics nature to produce synthetic crude oil, using organic materials or which can be further refined. Under heat and pressure, long chains of polymers begin to decompose, creating a synthetic crude oil.

Pyrolysis**:** Pyrolosis produces combustible tar/bio-oils and chars. Pyrolysis is the chemical decomposition of a substance by heating.

Pyrolysis is most commonly used for organic materials. It occurs spontaneously at high temperatures (i.e., above 300 °C for wood, it varies for other material), for example in wildfires or when vegetation comes into contact with lava in volcanic eruptions. It does not involve reactions with oxygen but can take place in the presence of oxygen. Carbonization is extreme pyrolysis, leaving only carbon as the residue, which is called charring.

Pyrolysis is heavily used in the chemical industry, for example, to convert ethylene dichloride into vinyl chloride to make PVC, to produce coke from coal to produce charcoal, activated carbon, methanol and other chemicals from wood, to convert biomass into syngas, to turn waste into disposable substances, and for the cracking of medium-weight oil to produce lighter hydrocarbons like gasoline.

Pyrolysis is an important chemical process in several cooking procedures such as baking, frying, grilling, and caramelizing. Pyrolysis is also a tool of chemical analysis, such as pyrolysis gas chromatography mass spectrometry and in carbon-14 dating. Many important chemical substances, such as phosphorus and sulfuric acid, were first obtained by pyrolysis.

Plasma Arc Gasification (PGP or Plasma Gasification Process): Plasma Arc Gasification produces rich syngas, including hydrogen and carbon monoxide usable for fuel cells or generating electricity to drive the plasma arch, usable vitrified silicate and metal ingots, salt and sulphur.

Non-thermal methods:

Aerobic digestion: Produces heat and other usable products and is commonly called composting. Depending on the volume and composition of the material being composted, temperatures can reach as high as 180 degrees Farenheight or more. In nature, many reptiles and birds use aerobic digestion to incubate their eggs. Historically, composting organic materials in a “jacket” around livestock watering tanks was used as a cost-effective method of preventing the watering tanks from freezing. Gardeners often use a heavy layer of organic material as a means of both insulating plants and generating a low degree of heat to keep frost at a minimum as it breaks down into compost.

Anaerobic digestion: Anaerobic digestion produces heat and biogas rich in methane. The cost of an anaerobic-digestion system can vary dramatically depending on its size, intended purposes, and sophistication. Under ideal conditions, an anaerobic-digestion system can convert a livestock operation's steady accumulation of manure into a fuel for heating or cooling a portion of the farm operation or for further conversion into electricity for sale to a utility. The solids remaining after the digestion process can be used as a soil amendment, applicable on-farm or made available for sale to other markets. Such ideal conditions seldom exist, in part because of faulty planning and design.

Each farmer's situation is unique, and as such, requires careful consideration of many factors. The size of the system is determined primarily by the number and type of animals served by the operation, the desired retention time and the amount of dilution water to be added. The most manageable of these factors is retention time; longer retention times mean more complete breakdown of the manure contents, but require a larger tank. Digesters must be airtight and able to be heated, usually with hot-water piping running in and out of the digester tank. Regular, not necessarily continuous, mixing of the digester's contents is important to maximize gas production. Because anaerobic digesters are expensive to install and manage, these considerations and many others should be researched and then factored into an economic-feasibility assessment.

Ethanol production: The fermentation of sugar into ethanol is one of the earliest organic reactions employed by humanity. The largest single use of ethanol is as a motor fuel and fuel additive. Gasoline sold in Brazil contains at least 25% ethanol and anhydrous ethanol is also used as fuel in more than 90% of new cars sold in the country. Henry Ford designed the first mass-produced automobile, the famed Model T Ford, to run on pure anhydrous (ethanol) alcohol, calling ethanol "the fuel of the future".

Mechanical biological treatment (MBT): A mechanical biological treatment system is a form of waste processing facility that combines a sorting facility with a form of biological treatment such as composting or anaerobic digestion. MBT plants are designed to process mixed household waste as well as commercial and industrial wastes. This method allows for the removal of non-organic components of the waste stream such as glass, metal, plastics, and other materials not compatible with aerobic or anaerobic digestion. Since these non-organic components may have a market value in themselves, the cost of producing energy using this method may be offset to some degree. In Delta County, as in any urbanized area, there is a substantial supply of waste material which can be used as technology and permitting standards develop.

Tires

The Delta County Landfill shipped out 2,395 waste tires in 2008, down from 3,441 in 2007. This is a typical cycle which is dependent on the shipping schedule more than on the availability of the tires.

New Page is permitted to burn 90 tons of tires per day, obtained from Wisconsin and from L'Anse, MI. The tires are chipped to a size, and blended with wood waste and paper mill sludge and coal in a combination boiler. By co-burning the tires using a mix of 65% wood waste, 25% coal and 10% tires at controlled temperatures, problems with particulate matter is eliminated. More of a problem is the wire within the tire, which can cause problems with various furnace types ranging from the fine wires creating "nests" to these wires actually melting and plugging the furnace grates, resulting in higher operating costs for the furnace.

Methane Generation

Methane is a landfill gas, a natural gas, and a manufactured gas. Currently, most of the manufacture of methane synthesized commercially is by the distillation of bituminous coal and by heating a mixture of carbon and hydrogen. The energy released by the combustion of methane, in the form of natural gas, is used directly to heat homes and commercial buildings. It is also used in the generation of electric power. During the past decade natural gas accounted for about 1/5 of the total energy consumption worldwide, and about 1/3 in the United States. In the chemical industry, methane is a raw material for the manufacture of methanol (CH_3OH), formaldehyde (CH_2O), nitromethane (CH_3NO_2), chloroform (CH_3Cl), carbon tetrachloride (CCl_4), and some freons (compounds containing carbon and fluorine, and perhaps chlorine and hydrogen). The reactions of methane with chlorine and fluorine are triggered by light. When exposed to bright visible light, mixtures of methane with chlorine or fluorine react explosively.

In 2008, the Delta County Landfill received 81,607 cubic yards of mixed household garbage. As it decomposes, this garbage produces methane. At the present time, this production is not cost-efficient to recover so it is being burned at a rate of 80 to 90 cubic feet per minute. When the landfill is capped in two to three years, the methane production will be at or approaching 150 to 175 cubic feet per minute, the required rate for cost-effective recovery.

The Escanaba Wastewater Treatment plant produces about 25,000 cubic feet of methane per day, according to Don French, Escanaba Water & Waste Water Superintendent.

Compost

Compost is currently not cost-effective as a commercially-viable heating fuel with current technology. As compost breaks down, one of the byproducts is heat. Compost bacteria is most efficient at approximately 140 degrees and composting in sufficient volumes can produce temperatures in excess of 180 degrees. The operative word is volume. While this heat can be captured, and has been used in a bygone era to keep watering troughs open during winter periods, the volume necessary to be viable for capture is currently not an efficient use of the material. In the future, technology may make it cost-effective to use compost as a source of operating low-heat, high-efficiency engines, but currently that technology does not exist.

Potential waste-to-energy (manure, stover, straw, etc.)

There is a substantial amount of waste material, primarily biomass, that can be used for waste-to-energy production or passive energy conservation. Corn and wheat stover (grain stalks left after harvesting) can be burned for fuel as can dried manure. (On the prairies of North America, during the westward migration, buffalo chips, or manure, were a primary source of fuel in the absence of trees.) Manure also can be processed in digesters to create methane. Wheat straw can be palletized or used for straw bale construction as described in a future chapter.

Below is the current data regarding the availability of non-forest biomass sources in Delta County which produce agricultural waste:

Farm Biomass: 74,272 acres identified as farms; average farm is 272 acres
Percent of farm land harvested cropland: 35.79% (26571 acres)
All wheat for grain: 604 harvested acres
Vegetables: 379 harvested acres
Land in orchards: 72 acres
Corn for grain: 2110 harvested acres

Cattle:	7,979 head	73,000 tons of waste/yr	18,000,000 gallons of waste/yr
Poultry:	874 head	39 tons of waste/yr:	9,400 gallons of waste/yr
Hogs:	230 head	440 tons of waste/yr	110,000 gallons of waste/yr
Sheep:	37 head	15 tons of waste/yr:	3,600 gallons of waste/yr

*Note: County totals are compiled using 1997 Census of Agriculture data.

Chapter 6. Passive Energy

Heat Capture through Cogeneration

Once a popular means of providing heat in U.S. cities, heat capture is one of those technologies worth considering in parts of Delta County. Estimates made last summer by MSU staff indicated that the Escanaba Power Plant could increase its efficiency from roughly 35% to nearly 90%. In addition, there appears to be some potential for capturing heat from other industries.

The use of a heat engine or a power station to simultaneously generate both electricity and useful heat is known as combined heat and power (CHP), or cogeneration. Generally, a conventional power plant emits the heat created as a by-product of electricity generation into the environment through cooling towers, as flue gas, or by other means. CHP or a bottoming cycle captures the by-product heat for domestic or industrial heating purposes, either very close to the plant, or for distribution through pipes to heat local housing.

Heat Capture via District Heating

Northern Europe and particularly Sweden have been using district heating for years. The fundamental idea of district heating is to utilize cheap surplus heat sources locally available to satisfy local heat demands. The cost of heat distribution disqualifies the use of expensive and easy-handling energy sources as light fuel oil, natural gas, or electricity as sole heat source in a district heating system.

Cheap surplus heat is available from various sources. The strongest driving force for district heating is the possibility of using heat rejected from thermal power stations (CHP- plants). Other heat sources that can be used in district heating systems are waste heat recovered from industrial processes and waste heat from refuse incineration. District heating can also be used to utilize cheap fuels that are difficult to handle and burn (as coal, wood waste and peat).

The energy sources used for heat generation in Swedish district heating systems have varied by the years due to variations in the prevailing conditions. This is especially the case with the utilization of combined heat and power and its relation to the Swedish power generation.

One of the keys to district heating is the efficiency of the insulation. While there are reports of Swedish-made insulation capable of only a two (2%) percent heat loss over a 25 mile distance, most of the data reviewed seems to indicate that the heat loss is variable and is usually between eight percent and twenty percent, dependent largely on the number of buildings on the system. Thus a system carrying hot water at 200 degrees is likely to lose 16 to 40 degrees or more over the length of the system. The age, color, and distance are all factors in the efficiency of the system.

Insulation
In the United States, buildings use one-third of all energy consumed and two-thirds of all electricity. Insulation and weatherization both work to conserve energy. Insulation functions by placing barriers to the different types of heat transfer. A brief description of these barriers and how they function follows:

Thermal radiation and radiant barriers
Thermal radiation is composed of all wavelengths of light, with most of the energy of the thermal radiation of objects at room temperature being in the infrared part of the spectrum. It requires no medium in which to travel. Any object above absolute zero radiates thermal radiation. The amount of energy radiated by an object is proportional to its surface temperature and its emissivity (a measure of a material's ability to radiate absorbed energy). As all objects radiate energy towards one another, the important consideration is the net direction of energy flow.

Thermal radiant barriers possess the characteristics of low emissivity, low absorptivity and high reflectivity in the infra-red spectrum. Only a small fraction of radiant energy is absorbed by such a material (most being reflected back away) and therefore only a small fraction is re-emitted. Highly-polished metals and light-colored materials are examples. Conversely, dark materials with low reflectivity will absorb a large fraction of energy, and similarly emit a large fraction.

Thermal radiation and radiant barriers
Conduction occurs when heat moves through a medium. The rate at which this occurs is proportional to the thickness of the material, the cross-sectional area over which it travels, the temperature gradients between its surfaces, and its thermal conductivity.

Air and most gases are poor conductors, and thus are good insulators. Conductive barriers often incorporate a layer of air to reduce heat transfer as in the case of Styrofoam and double-glazed windows. Conductive heat transfer is largely reduced by the presence of the air-filled spaces rather than by the material itself. Because metal is a good conductor, reflective foil needs an air gap to function adequately as a conduction insulation material. A radiant barrier system is defined as a reflective material facing an air space. When the radiant barrier faces an enclosed air space it becomes a reflective insulation with a measurable R-value.

Thermal conduction depends on size. A small insulator is less effective than a large insulator.

Convective transfer and convective barriers
Convective heat transfer occurs between two objects separated by a moving interface of liquid or gas. Convective currents driven by heat energy occur between the objects. The physical properties of the fluid or gas and the velocity at which the molecules travel influence the rate of transfer. Convection can be reduced by preventing large currents from forming.

Combined barriers
The materials used to reduce conduction also decrease convection. The small air spaces retard convective movement. There is an ideal density of the material which maximizes both effects simultaneously (e.g., the reflective surfaces and vacuum in a vacuum flask).

Factors impacting insulation
Moisture compromises insulation. Damp materials may alter most of their insulating properties. The choice of insulation can depend on managing moisture and condensation on one side or the other of the thermal insulator. Clothing and building insulation depend on this aspect to function.

Insulating Materials
Materials used for insulation vary according to whether or not they are structural or non-structural.

Structural insulation materials include rigid and structural panels of foam or similar material, and straw bale insulation.

Rigid panels
Rigid panel insulation is made from fibrous materials (fiberglass, rock and slag wool) or from plastic foam.

Structural insulated panels
Structural insulated panels (SIPs), also called stressed-skin walls, extend the concept of foam-core construction to the entire house. They can be used for ceilings, floors, walls, and roofs. SIPs usually consist of outer layers of construction material (plywood, oriented strandboard, or drywall) glued and sandwiched around a core consisting of expanded polystyrene, polyurethane, polyisocyanurate, compressed wheat straw, or epoxy. Epoxy is too expensive to use as an insulator on its own, but it has a high R-value (7 to 9), high strength, and good chemical and moisture resistance. SIPs come in various thicknesses. Glued together and secured with lumber, they provide the structural support, rather than the studs used in traditional framing.

Strawbale Construction
Straw bale construction is an old construction method regaining popularity in passive solar and other renewable energy projects. Given a bad image by the popular “Three Little Pigs” fairytale, straw bale construction is a proven cost-effective and efficient construction method. When bales are used to build or insulate buildings, the straw bales are commonly finished with plaster or stucco. The plastered walls provide excellent thermal mass, compressive and ductile structural strength, as well as thermal resistance (insulation), far in excess of North American building code. Straw bales offer excellent insulation. At R 2.7 per inch, an eighteen-inch wide bale equals R-48. One study indicated that such a "super-insulated" straw bale home could save as much as 75% of heating and cooling costs.

Straw is an abundant agricultural waste product, and requires little energy to bale and transport for construction. Because the straw bales are encapsulated in plaster or stucco and do not allow airflow, the fire resistance of straw bale construction meets and usually exceeds that of conventional construction methods.

Wheat straw is the most commonly used type of straw, but is also produced by barley, oats, rye and several other grain corps. Roughly one half of the weight of a harvest in Delta County produces 604 harvested acres of wheat for grain, which translates to 604 acres of straw, now largely used for animal bedding.

Non-structural Insulation Materials

While there are numerous types of insulation materials available, only the most common types are discussed here. Batt insulation is the most common at this time, though batts generally allow for more air transfer than other options. Options that seal the wall cavity completely may have some heat loss through studs and joists due to heat bridging, though this is likely to be a lesser issue than air transfer.

Rock wool batts:

Usually made from rock (basalt, diabase) or iron ore blast furnace slag. Some rock wool contains recycled glass. Rock wool is nonflammable.

Fiberglass batts:

Fiberglass is made from molten glass, usually with 20% to 30% recycled industrial waste and post-consumer content. It is nonflammable, except for the facing, which may be treated to be fire-resistant. Fiberglass may be un-faced, paper-faced with a thin layer of asphalt, or foil-faced. Paper-faced batts are vapor retarders, not vapor barriers. Foil-faced batts are vapor barriers.

Loose-fill insulation materials (including Cellulose insulation):

Loose-fill materials can be blown into attics, finished wall cavities, and hard-to-reach areas. Loose fill insulation is used when there is a need to conform to spaces and fill in the nooks and crannies. Loose fill insulation can also be sprayed in place, usually with water-based adhesives. Many types are made of recycled materials (a type of cellulose) and are relatively inexpensive.

Spray Polyurethane Foam (SPF) Insulation:

Typically used for large- to mid-scale applications, Spry Polyurethane Foam is a two component mixture that comes together at the tip of a gun, and forms an expanding foam that is sprayed onto concrete slabs, into wall cavities of an unfinished wall, against the interior side of sheathing, or through holes drilled in sheathing or drywall into the wall cavity of a finished wall. The expanding foam fills voids and spaces in the wall preventing cold spots.

Weatherization

Weatherization (or weatherproofing) is the practice of modifying a building to reduce energy consumption and optimize energy efficiency, thereby protecting the building and its interior from the elements, particularly from sunlight, precipitation, and wind.

Weatherization is distinct from building insulation, although building insulation requires weatherization for proper functioning. Many types of insulation can be thought of as weatherization, because they block drafts or protect from cold winds. Whereas insulation primarily reduces conductive heat flow (heat moving from molecule to molecule rather than by the movement of the molecules), weatherization primarily reduces convective heat flow (heat transferred by means of the movement of molecules within fluids, i.e. liquids, and gases).

In the United States, buildings use one-third of all energy consumed and two-thirds of all electricity. Additionally, they are a major source of the pollution that causes urban air quality problems and pollutants that contribute to climate change. Buildings account for 49% of sulfur dioxide emissions, 25% of nitrous oxide emissions, and 10% of particulate emissions.

Chapter 7. Other Mechanical/Chemical Technology

With the exception of Hydroelectric power generation, none of the Mechanical/Chemical Technologies are being produced in Delta County at the present time. This presents an opportunity for Delta County entrepreneurs to exploit.

Hydrogen

Hydrogen (H2) is being aggressively explored as a fuel for passenger vehicles. It can be burned in internal combustion engines or used in fuel cells to power electric motors. Before this environmentally-friendly fuel that has the potential to dramatically reduce our dependence on foreign oil can be widely used, several significant challenges must be overcome. Hydrogen fuel is currently costly to produce. Vehicles are only available to a few demonstration fleets being too expensive for broad scale commercial development, and are not energy efficient.

On the plus side, hydrogen can be produced domestically from several sources, reducing our dependence on petroleum imports. Also, Hydrogen produces no air pollutants or greenhouse gases when used in fuel cells.

Fuel Cells

While perhaps not a factor in the immediate future of Delta County, fuel cells have been around for a long time, the principle first being discovered in 1838 and first demonstrated in 1839. There are currently about 20 types of fuel cells at the present time using various fuels including microbial cells and cells that use methanol.

A fuel cell works by catalysis, separating the component electrons and protons of the reactant fuel, and forcing the electrons to travel through a circuit, hence converting them to electrical power. The catalyst typically comprises a platinum group metal or alloy. Another catalytic process puts the electrons back in, combining them with the protons and oxidant to form waste products (typically simple compounds like water and carbon dioxide).

As technology advances in fuel cell construction, Delta County could see the development of either a fuel cell manufacturing plant or more likely a fuel cell cogeneration plant to serve as an emergency back-up to critical services such as the hospital.

While automobiles using fuel cells have been experimented with, fuel cells have not proven a viable means of powering automobiles to date. The problem with fuel cells is the relatively short distance that fuel cell powered vehicles are capable of traveling, making them a cost-inefficient method of transportation at the present time. As fuel cells are further developed, this may change.

Storage Batteries

Currently, there are no manufacturers of storage batteries in Delta County. This technology has the potential of being expanded upon or improved using one of the Universities in the Upper Peninsula. At the present time, Michigan State University is experimenting with improved energy lithium ion batteries, and four manufacturers of batteries are looking at sites in the southern tier of counties in the Lower Peninsula.

Batteries have been around a long time. A curiosity found in Baghdad in 1932 was probably representative of laptop battery technology from about 2500 years ago. The primitive battery cell comprised an iron rod that fit into a copper cylinder. When exposed to an electrolyte, a current could be produced.

The modern rechargeable battery, also known as a storage battery, is technically a group of two or more secondary cells, such as laptop batteries containing six individual cells. The term is often used to refer to a single cell, AA battery. These batteries can be restored through a battery charger to full charge by the application of electrical energy. These batteries, in which the electrochemical reaction that releases energy is readily rechargeable, come in many different designs using different chemicals. Compared to disposable batteries, rechargeable batteries can offer some economic and environmental advantages. Rechargeable batteries are available in the same sizes as disposable batteries (e.g. AA, AAA, CR123A). While the initial cost is higher, rechargeable batteries can be recharged many times. The extended life of these batteries can reduce toxic materials sent to landfills compared to disposable batteries.

Stirling Engines

Robert Stirling was a minister of the Church of Scotland who was interested in the health of his parishioners' bodies in addition to the well being of their souls. He invented the Stirling engine (he called it an "air engine") because steam engines of his day would often explode, killing and maiming those who were unlucky enough to be standing close by. Robert Stirling's engines couldn't explode and produced more power than the current steam engines at the time. In 1816, Stirling received his first patent for a new type of "air engine". The engines he built and those that followed eventually were known as "hot air engines" until the 1940's when other gasses such as helium and hydrogen were used as the working fluid. Robert Stirling was an active minister and inventor all his life. Perhaps his most important invention was the "regenerator", or "economizer" as he called it. This is used today in Stirling engines and many other industrial processes to save heat and make industry more efficient.

The Stirling cycle uses an external heat source, which could be anything from gasoline to solar energy to the heat produced by decaying plants. No combustion takes place inside the cylinders of the engine. For these reasons, the Stirling engine has the potential to be much more efficient than a gasoline or diesel engine. At the present time, Stirling engines are used only in some very specialized applications, like in submarines or auxiliary power generators for yachts, where quiet operation is important. To date, there hasn't been a successful mass-market application for the Stirling engine.

Hydro Electric Power

Currently Delta County has three producing hydro-electric dams:
Escanaba River Dam #1: producing 1.95 MW; 2 miles from the mouth of the river
Escanaba River Dam #3: producing 2.5 MW; 5 miles from the mouth of the river
Escanaba River Dam #4 (Boney Falls): producing 4.74 MW; located 22 miles from the mouth of the river.

Chapter 8: Transmission Capacity

Without the ability to transport energy, all of the energy production in the world is relegated to local production and use. This said, energy production, whether electrical energy or liquid energy, is a balancing act between the ability to produce power and the ability to transport that energy by means of electrical lines, pipelines, ship, rail or truck transport.

Electrical Transmission

Electricity requires that there be adequate electrical transmission lines sized to carry the loading that would be put on them. In Delta County, most of the lines have either a 69 MW or 138 MW capacity. Upgrading these lines would cost more than $1.6 million per megawatt. While there are currently, as of June 5, 2009, two large facilities under study, power supplies of this size will be in excess of the capability of most of the existing transmission systems. This means that either the transmission lines will need to be resized to carry the additional load, or a number of smaller generation facilities will need to be placed strategically to utilize the existing transmission systems.

The federal government has recognized that the high-voltage power grid is in need of a nationwide upgrade. Bills have been introduced to address the need to redesign and rebuild the nation's high-voltage power grid to deal with both conventional and alternative energy production. Currently, reconstruction of the power grid costs approximately $1.6 million per mile. This reconstruction will require advances in technology, increased manufacturing of parts for transmission equipment, and job training for construction workers and technicians to build and keep the system maintained.

Pipelines

Currently, there are no commercial pipelines in the Upper Peninsula suitable for transporting liquid bio-fuels any significant distance. Until there is sufficient liquid bio-fuel production, the optimum way to transport liquid bio-fuels in commercial quantities would be via rail or in some cases by ship.

Solid Bio-fuels

Solid bio-fuels are best shipped by truck, rail, or ship. Delta County is fortunate in that it has a deep water port, rail facilities (which could be modified to handle solid bio-fuels), and highways which can be used to transport fuels.

Chapter 9. Concluding Remarks

If there is one thing to be learned from assessing the potential for alternative energy in Delta County, it is that alternative energy is continually advancing. There appear to be four major factors related to energy in Delta County, and by extension, in Michigan, the nation and the world. These are developing technologies, new resources, transmission of energy, and jobs created by energy. As this study is being completed, various groups are working on energy efficiency and production ranging from such diverse fields as nano-technology, to improved wind energy turbine design, to the capture of energy from space. Some of these technologies will never develop and some of them will lead to dynamic changes in the next few years.

In addition to new technologies, is the potential to improve the output and efficiency of old or existing technologies. Wind power for example has been in use for thousands of years, but new advances in turbine and vane design, bearing, and towers have taken it from grinding grain to powering cities. The Stirling engine was invented roughly 200 years ago, and has been used primarily to capture waste heat on submarines. It was first theorized by A.E. Becquerel in 1839 and first produced in 1883. It wasn't until 1954 that the technology became commercially viable and new advancements are occurring in solar cell production every day.

High velocity wind is not likely to be a competitive resource unless wind farms are developed off shore in Lake Michigan where sustainable wind velocities are sufficient to develop into a utility. Low velocity wind has greater potential inland. It may be that at some point in the future, low velocity wind will be a viable economic alternative for producing power in wind communities of lesser size than is currently envisioned as a wind farm utility based on sustainable high velocity winds. Technology seems to be rapidly developing in that direction.

Solar energy has increasing potential as technology advances. Delta County has an average of 186 sunny days. New technology such as flexible photovoltaic cells and new methods of optimizing the older technologies make solar energy an increasingly viable energy resource in areas difficult to serve by other means.

Delta County has a wide variety of energy potentials. Most prominent is the ability to use and develop bio-mass. Not only are there a number of existing bio-mass energy resources, there is also substantial potential to develop or at least explore the development of new bio-mass energy resources such as hybrid willow, and camelina. In addition to new bio-mass resources there is significant potential to optimize the current biomass resources such as wood slash and crop stover which are currently viewed primarily as waste products. In the future, it is very likely that the logging industry will develop or adopt new technology which will allow the efficient collection of the wood slash that is currently being left on the ground as a by-product of pulp and timber harvesting.

Geo-thermal ground heat is just beginning to gain a foothold in Delta County. While there are no volcanic based heat sources capable of producing power through conventional means in Delta County, as ground heat geo-thermal technology progresses, the overall cost efficiency should make this energy resource increasingly popular.

The vast amounts of waste currently being land-filled are a major energy resource, as well as a land use problem. Much organic matter can be burned directly for energy or will decompose naturally or artificially to create methane. Certain waste products, such as most plastics, are directly derived from oil and can be used to produce energy with only modest changes in current technology. Tires are already being used in the New Page paper plant along with a mixture of wood waste. While composting is not currently a commercially viable energy source, the biological decomposition of organic waste also creates substantial amounts of heat that may one day be a viable energy resource.

Capturing, conserving and transmitting energy are less glamorous but equally important factors in the field of alternative energy. Currently the UP has limited transmission capability with most power lines rated at 69 KV topping out at 138 KV. This means that with the current transmission capacity any new power plants using the Delta County transmission lines should produce under 69 KV. The efficiency of plants which make electricity using external heat to power the generators can be significantly increased by co-generating both electricity and captured heat. Increases in technology and insulation have extended the ability to transport captured heat, often in the form of hot water from roughly a mile to as much as 25 miles in northern European countries. This in turn can reduce the cost of heating homes and businesses and further reduce the use of fossil fuels. The simplest form of reducing the cost of fuel for most homeowners is to weatherize and insulate their homes.

New and old forgotten technologies are showing more and more value on a national basis. These same technologies can be readily adapted to production and use in Delta County. Stirling engines, fuel cells, and high efficiency batteries are just a few of the types of energy technology that we may see in the not too distant future. Some of these, such as the Stirling engine invented in 1816 and the solar cell or photovotaic cell was first recognized in 1839 and first constructed in 1883.

The age of alternative energy is not new, nor is it nearing maturity. It is, however, being forced on the world's population as conventional sources of energy become too costly to maintain. Fossil fuels are a finite resource. As supplies decrease, the cost of using these conventional energy resources will continue to increase, in addition to the environmental costs of conventional energy sources.

Ironically one of the greater dangers to Global warming appears to be an energy resource itself. Methal Hydrate, or frozen methane releases methane, a dangerous greenhouse gas when it reaches normal temperatures. Methane is released as permafrost melts and also it is feared that a global warming may allow vast amounts of methal hydrate to gassify from the oceans with much greater impacts on global warming than equal amounts of carbon dioxide. Yet methane can be burned with less environmental impact than petroleum fuels.

When considered in its relationship to Delta County, Michigan, this continually emerging field of alternative energy is going to have a major impact. Delta County has the potential to produce energy from biomass, waste, and captured heat. It has the potential to create new employment by manufacturing products to generate, conserve or more efficiently use alternative energy resources, and it has the ability to benefit from new and re-discovered sources of alternative energy.

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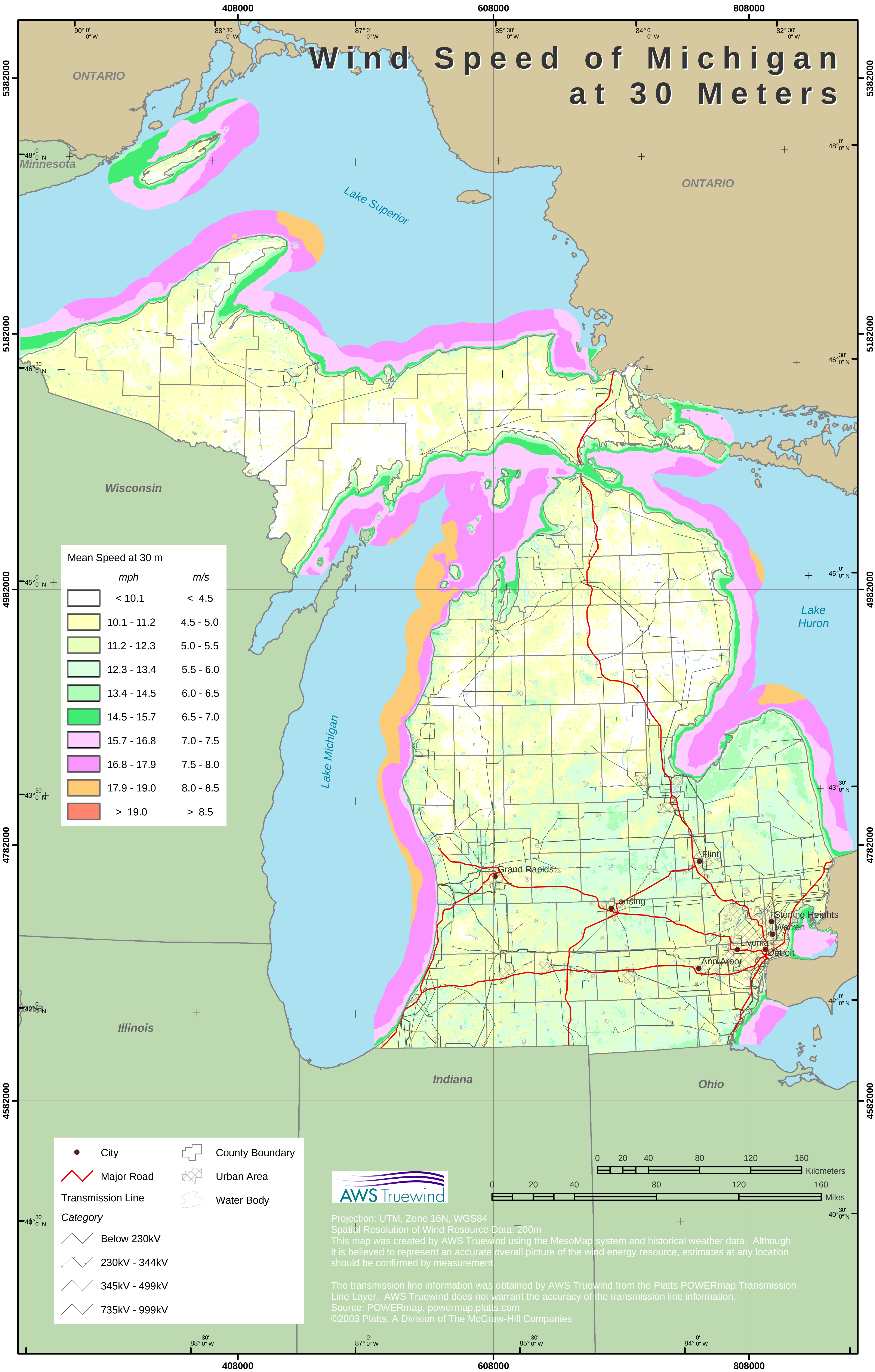

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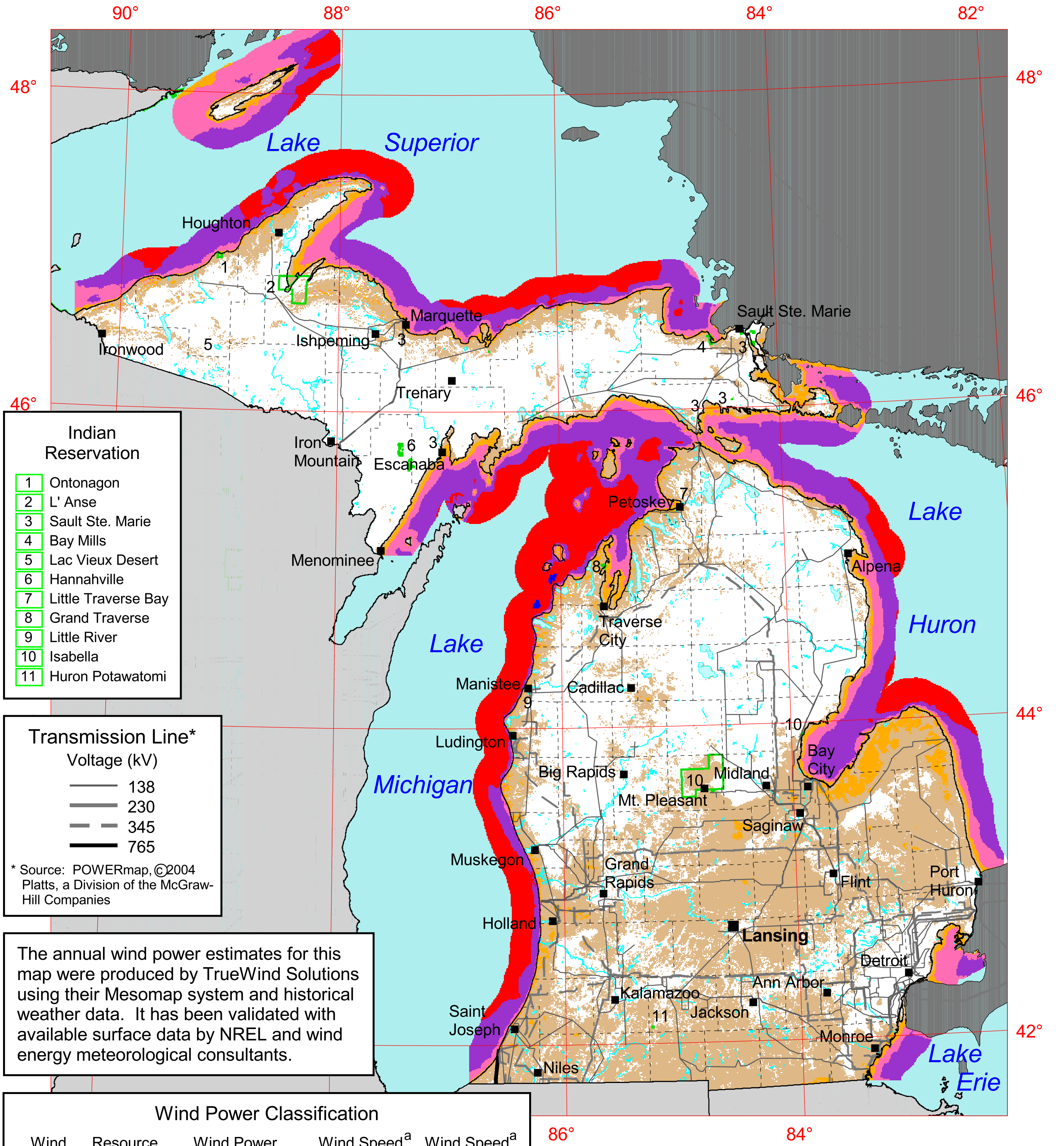
Michigan - 50 m Wind Power



The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.

Wind Power Classification

Wind Power Class	Resource Potential	Wind Power Density at 50 m W/m[2]	Wind Speed[a] at 50 m m/s	Wind Speed[a] at 50 m mph
1	Poor	0 - 200	0.0 - 5.6	0.0 - 12.5
2	Marginal	200 - 300	5.6 - 6.4	12.5 - 14.3
3	Fair	300 - 400	6.4 - 7.0	14.3 - 15.7
4	Good	400 - 500	7.0 - 7.5	15.7 - 16.8
5	Excellent	500 - 600	7.5 - 8.0	16.8 - 17.9
6	Outstanding	600 - 800	8.0 - 8.8	17.9 - 19.7
7	Superb	> 800	> 8.8	> 19.7

[a] Wind speeds are based on a Weibull k of 2.0.

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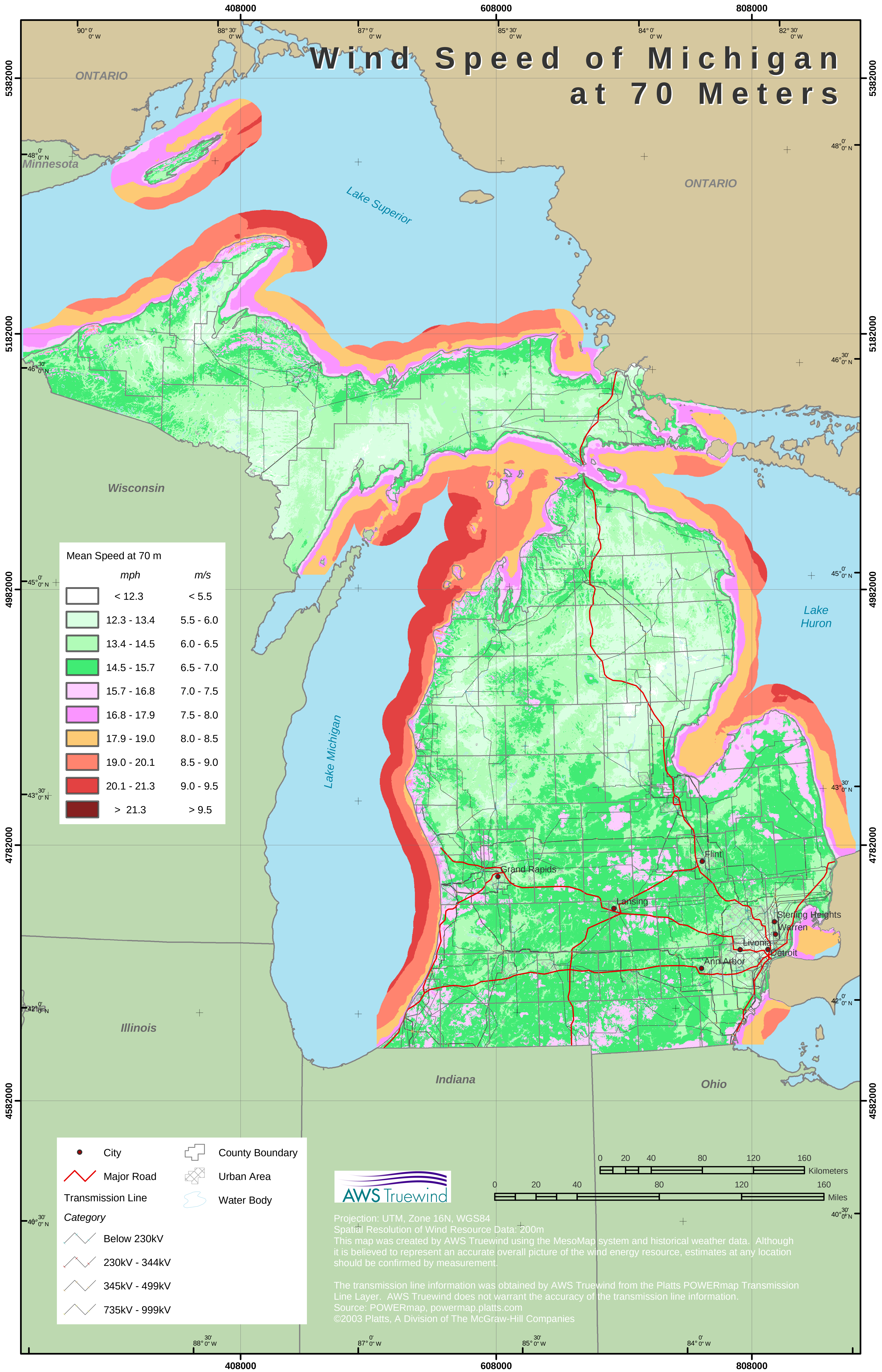

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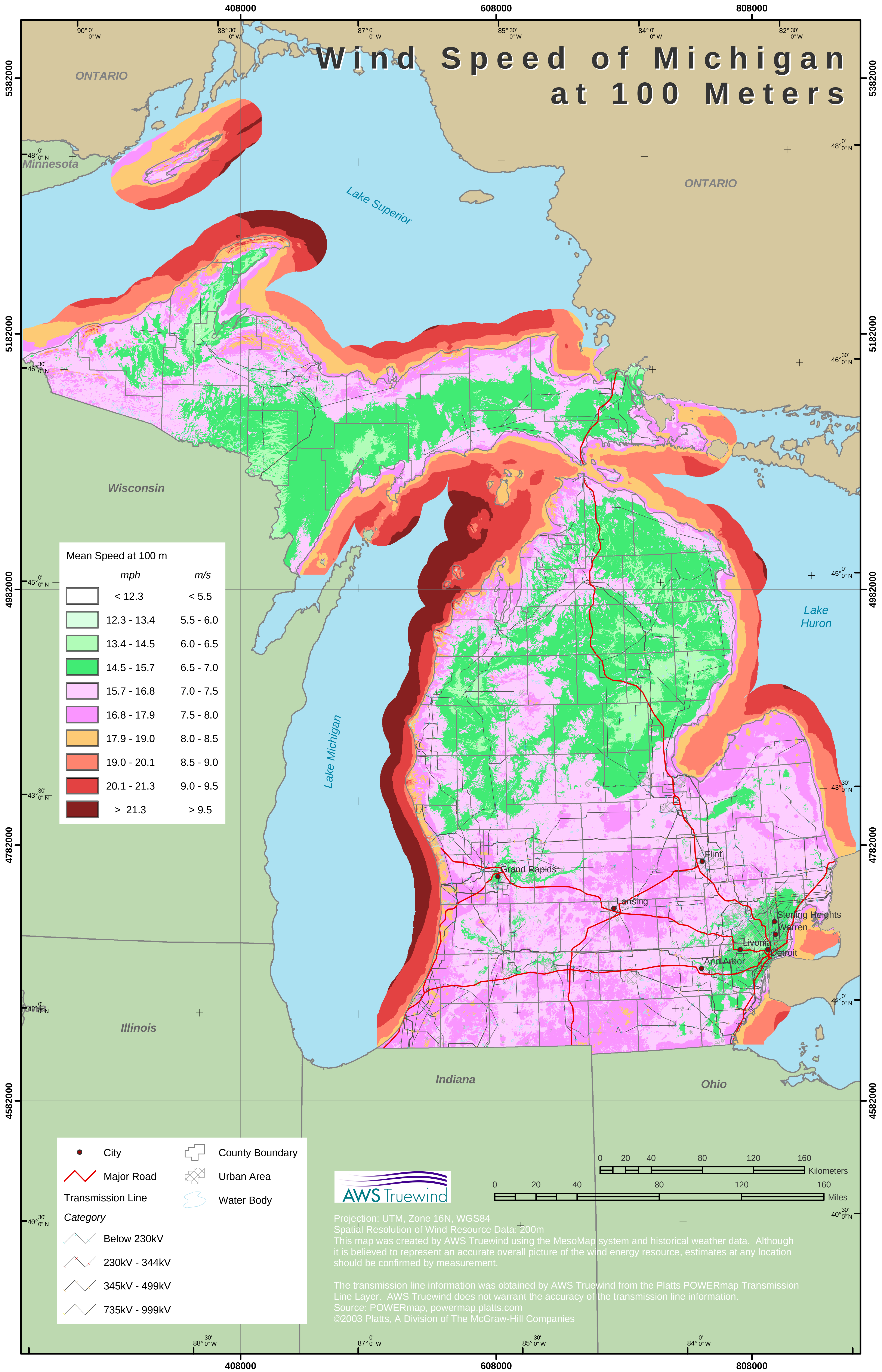

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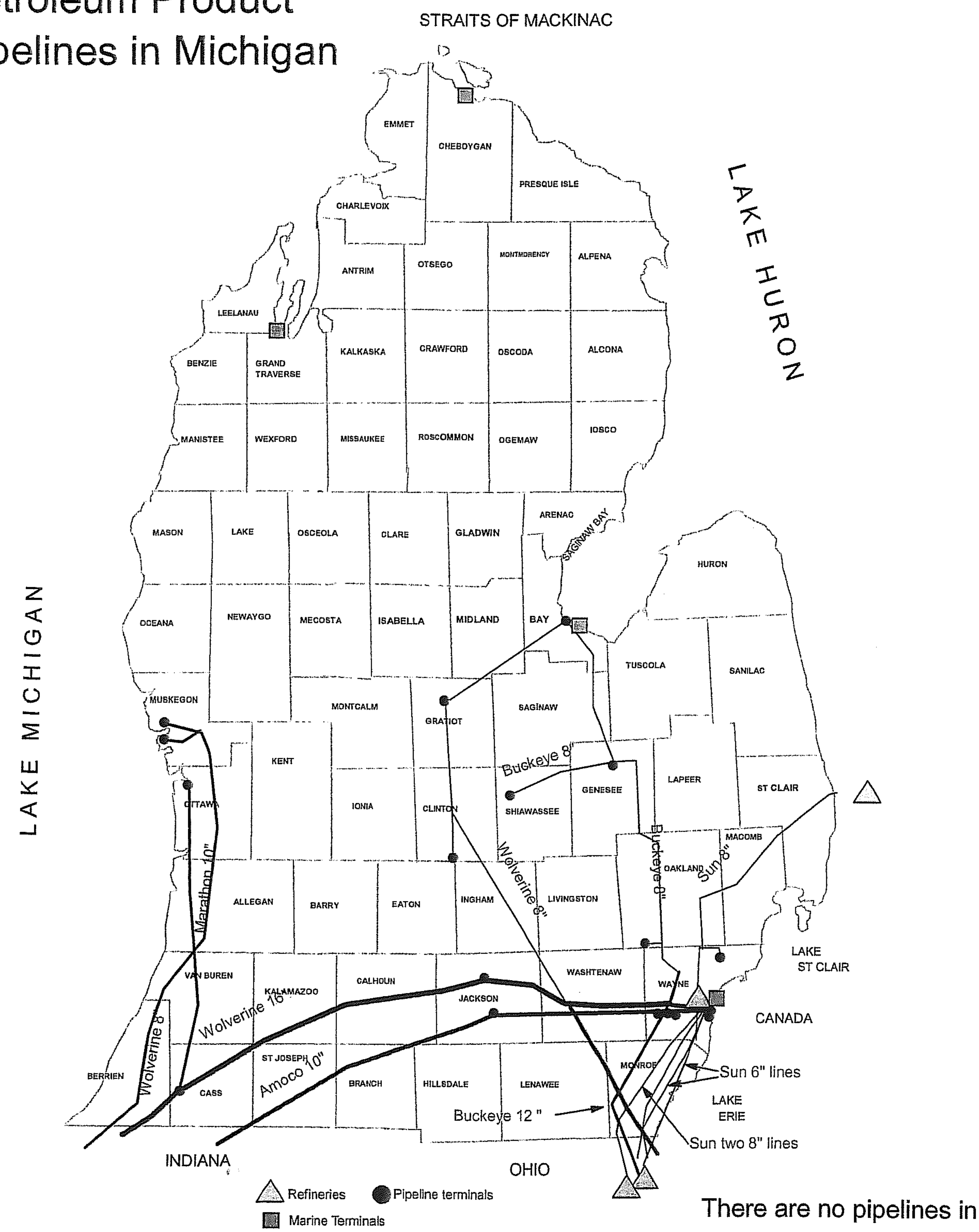
Petroleum Product Pipelines in Michigan



There are no pipelines in the Upper Peninsula

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