UMORE PARK - INTEGRATING SOLAR

Overview, Solar Optimization & Technologies, & Recommendations

Location:
RoseMount, MN
University of Minnesota

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Image from Co.Creative

INTRODUCTION:

Currently, it is estimated that buildings contribute to nearly one third of the total global greenhouse gas emissions. Our global economy is becoming more aware of approaches that not only help to reduce the impact of our built environment but we are also investing more research and development of renewable resource technologies. Integrating passive design techniques as well as designing for the optimization of renewable resource technologies will not only contribute to the reduction of greenhouse gasses but will also help to bring communities together by contributing to the underlying human goal: health.

It's clear that the rising demand for harvesting renewable energy and investing in green building can be partially attributed to the desire to reduce energy costs, however more altruistic benefits remain at the heart of the production. Sustainable buildings and homes are becoming an integral part of the design inception as the yearning for non-toxic forms of building materials and finishes prove to be a component in healthy buildings. Sustainability, meaning literally to continue contributing to the needs of now while not degrading the needs of the future, has benefits far beyond reduction of greenhouse gasses, energy savings and physical health. Its impacts become an integral form of contribution for our communities and overall society.

The University of Minnesota has been conducting research on sustainable communities for the past 30 years. In December of 2008, the Board of Regents approved a plan for the development of a 5,000-acre site owned by the University titled: The University of Minnesota Outreach, Research and Education (UMore) Park. The vision for UMore Park is to not only meant to be a University-founded community but is also meant to exemplify a community based around modern sustainable principles and innovations in "…renewable energy, education, environmental quality, transit, technology, housing and other University mission strengths... [while] contribute[ing] to a vital regional economy characterized by thriving businesses, and educational, social and natural amenities."

UMore Park Is currently researching renewable resources as means to providing 100% of the energy needed for the community. Wind and Biogas generation are two methods integrated into UMore Park's projected energy budget however solar power harvesting has yet to be thoroughly integrated as research within the energy budget for the projected community. Solar Power is becoming the most affordable and rewarding renewable technology. The sun, beaming onto Earth more than enough energy to satisfy global energy needs for an entire year all within one hour —makes solar an incredible renewable resource that is researched more thoroughly for UMore Park in this report.

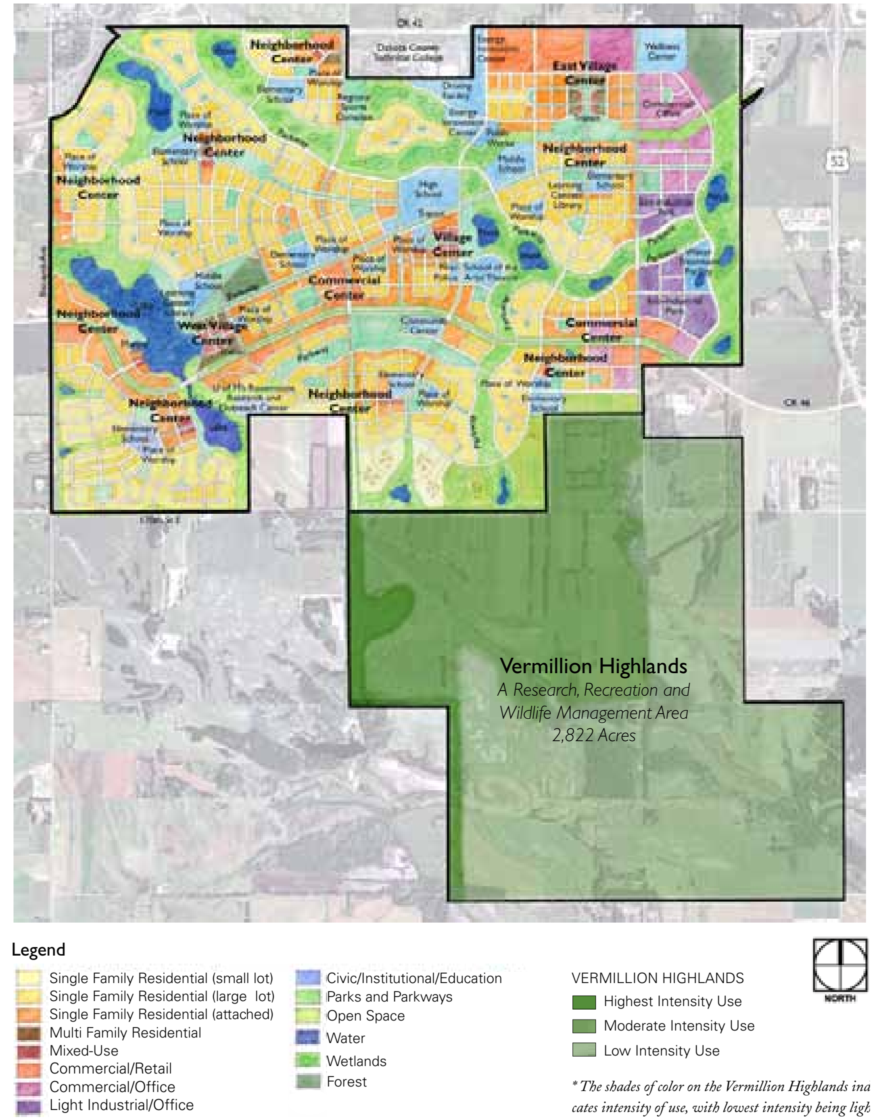
UMORE PARK OVERVIEW:

UMore Parks's vision for the future is based on the notion of being self-sustaining and utilizing modern innovations in sustainability. They project that the community will evolve into a development of nearly 20,000 to 30,000 people over a 25-40 year time-frame. The integration of innovative renewable energy, education, environmental quality, transit, technology, housing and other University mission strengths, would contribute to a community where sustaining prosperity, business, education, social and natural amenities become a common goal, improving health and wellbeing.

The 2008 conceptual master plan features projections of nearly 13,000 houses plus multi-family dwellings, neighborhoods blending mixed-use commercial and retail amenities, 1,000-acres of open space, an Eco-industrial park to locate R&D-based companies, and Office and wellness complex incorporating professional offices and health and wellness facilities. On a broad spectrum, the integrity of these goals were derived from principles involving educational, economical, and political respects to action that are based around UMore Park's Board of Regents guiding principles while also integrating statewide goals for bettering the communities of tomorrow.

UMore Park is located in the center of Dakota County, one of the fastest growing counties in the state. The Dakota County population is projected to grow from its current population of more than 371,000 to nearly 510,000 by 2030. Being equally near Minneapolis and St. Paul, being situated off of a major transportation corridor, and being surrounded by both suburban developments as well as agricultural land, the site makes for a desirable enough location that would attract both suburbia enthusiasts and city commuters. As if the overall objective to live in a sustainable and supportive system that would be designed to operate as an autonomous or closed loop system with the lowest energy requirements and minimal environmental disruption isn't enough, then people would come to live in UMore Park because it's distinct characteristics.

UMORE PARK MASTER PLAN



A variety of native gardens can serve as both public parks and habitat for wildlife. The Woodland Garden is currently located near the UMore Park/ Rosemount Research and Outreach Center Administration Building.

Single rows of trees separate farm fields, providing little vegetative cover for animal species.

Southwest of the UMore Park property, the Vermillion River creates a sizable pool of water.

The integration and application of the University's research combined with public information and education that will enrich the community at UMore Park is fully engrained within the concept master plan. Additionally, the design team with UMore Park has detailed analyses and recommendations on ways that the University, in partnership with numerous organizations in the public and private sectors, can infuse unique benefits into the community and create models that can be applied elsewhere. This plan strives to exceed the qualities of conventional master planned communities, especially through University programming and collaborations, with particular attention to:

Health and wellness with an emphasis on prevention, the opportunity to nurture, sustain and enhance human health and well-being can be addressed through a core focus on community, family and home – the bases of social connectedness.

Education and lifelong learning. From early childhood through the older adult years, this learning community would offer its members an array of educational opportunities, all of which will reflect the commitment to educational excellence and equity for all.

Environmental stewardship. The plan reflects the University's vision to create a community over time that would simultaneously implement sustainable practices on the landscape, be a platform for ongoing University research in natural resources and ecology, and educate the public about the benefits that can be derived from a focus on environmental quality and sustainability.

Balance of housing, jobs, amenities, services and open space. Consistent with University aspirations, the new community should be diverse in all ways – in age, gender, ethnicity, race, income, housing, employment and recreation opportunities and lifestyles. The creation of jobs and the commitment to open space help to ensure that residents can work and play in the community where they live.

Walkable and connected neighborhoods with innovations to reduce automobile dependency. The academic mission focus on health and wellness inspires a plan where all ages can walk to schools, work and retail shops through safe pathways that take advantage of natural landscapes and vegetation.

Economic contributions. The new community will contribute to regional economic development through unique community characteristics that are linked to University discovery, programming and lifelong learning as well as opportunities to locate light industry, businesses and service providers and support entrepreneurs.

Sustainability. The plan integrates environmental, socio-cultural and economic opportunities with a specific focus on innovation in education and lifelong learning, health and wellness, renewable energy, the natural environment, quality of life and regional economic development.

Energy. The renewable resource goal for the community is production of its own energy from sun, wind and biomass. Dwellings and other buildings would be constructed with materials and technologies that are energy efficient, energy producing and that conserve water.

With the broad spectrum of information regarding UMore Park's direct plan of action for a healthy and sustainable community, solar optimization and solar technologies seems to have by-passed focus. Therefore, the integration of solar power for UMore Park is a topic that needs to be investigated. The landscape, being 70% cultivated land, means that almost 4% of the property is covered in trees giving UMore Park a great opportunity to design within the framework for optimal solar design. Whether through passive techniques or solar technologies, UMore Park is a prime location for solar design within its master plan and structures. The following research is meant to be a direct reference for the UMore Park Committee to help with solar design parameters.

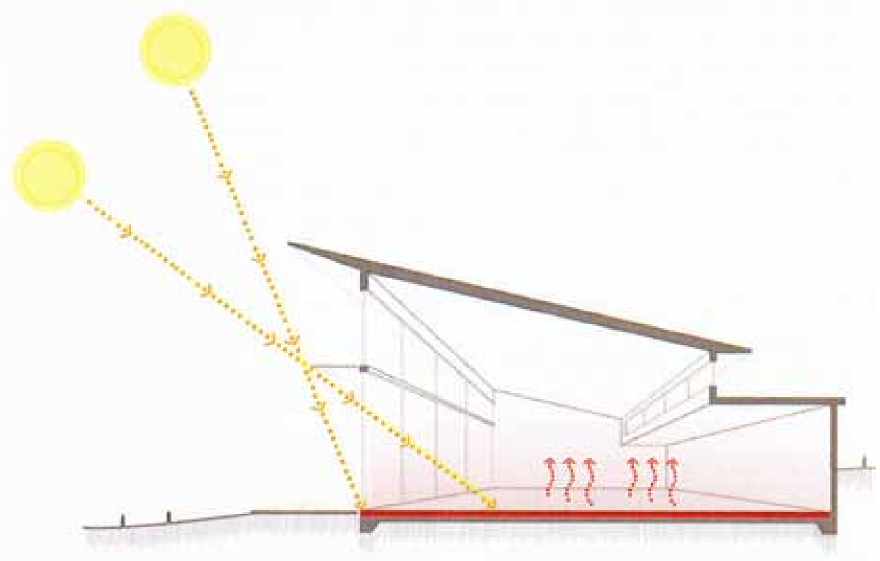
Type	Percent of the site	Acres
Water	0.0%	1.1
Shrubland	0.1%	3.9
Forests	1.5%	73.9
Woodland	1.8%	89.0
Herbaceous	7.9%	387.4
Artificial Surfaces and Associated Areas	17.9%	875.6
Planted or Cultivated Vegetation	70.7%	3,457.0

SOLAR OPTIMIZATION:

Every hour the sun beams onto Earth more than enough energy to satisfy global energy needs for an entire year. Solar energy is the technology used to harness the sun's energy and make it useable. Today, the technology produces less than one tenth of one percent of global energy demand. Solar technologies are becoming increasingly popular as the affordability and easability of owning such devices becomes easier. The technologies are making solar the most affordable and rewarding renewable resource available. It is important however that we take into consideration solar optimization at the onset of the design. By designing our spaces passively first and foremost, we will be able to create buildings that operate at a higher level without any renewable technology added. Good orientation, location on site, and landscaping changes may potentially reduce the energy requirements of a typical dwelling by 20 percent. Ensuring that the structure has a tight envelope is oriented to the south with a larger amount of southern fenestration while the northern side has very minimal openings, and potentially using thermal massing techniques along with smart systems and passive landscaping strategies, we are able to lower the costs of our project significantly by lowering the amount renewable technologies needed.

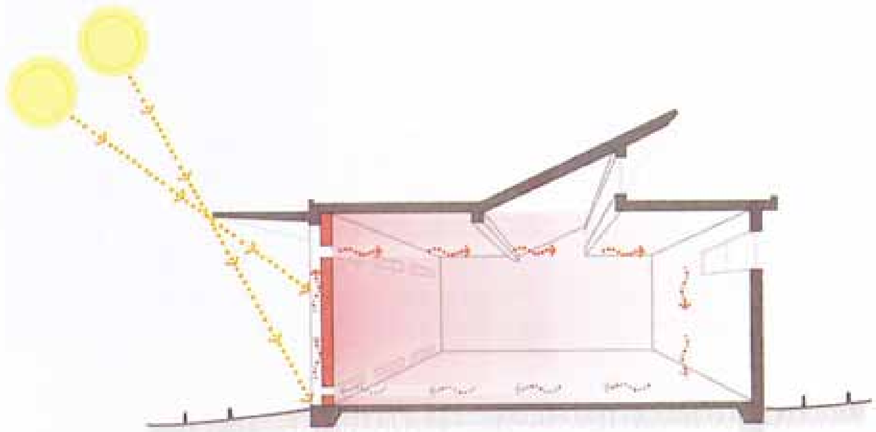
PASSIVE SOLAR

Passive solar design has been around since the need for shelter. Vernacular architectural design strategies have helped to evolve our built environment by optimizing and harnessing nature to work with our structures instead of opposed to it. In Minnesota, it's important to acknowledge that our built environment is designed around heating. Therefore, the Green Studio Handbook mentions, "In single-family homes, heating loads tend to be larger than cooling loads (except in very mild or hot climates). " The book goes on to state that the easiest way to heat a building is with direct solar gain. The solar radiation is admitted during the heating season and stores it thermally within thermal massing materials. This direct-gain technique is most successful with a tight-envelope that has a high R-Value with efficient windows. More specifically, "the building axis for a direct gain system should run generally east-west to maximize solar exposure (and heat gain) on the south-facing aperture. As long as the aperture is within 15° of true south (or north, in the southern hemisphere), the building will receive roughly 90% of the maximum winter solar heat gains. Shifting the aperture toward the east or west will somewhat shift the timing of these heat gains." When utilizing this technique, the best area would be one where occupants are free to move as conditions evolve over the course of a day. Distributing functional spaces is an important decision when utilizing direct gain. Southern facing spaces will benefit from direct solar heating while the northern facing spaces will not. Daylight will also be greater in southern facing spaces. Its wise to consider southern facing spaces as flexible spaces and northern facing spaces as buffer zones (i.e. closets, bathrooms, circulation, service spaces) creating a reduction in heat transfer from the south to the north. During the cooling season, solar radiation can be blocked with appropriate shading devices (including landscaping) while also coordinating the prevailing summer wind directions for passive cooling with the elongated southern exposure will help to reduce heating in the night.

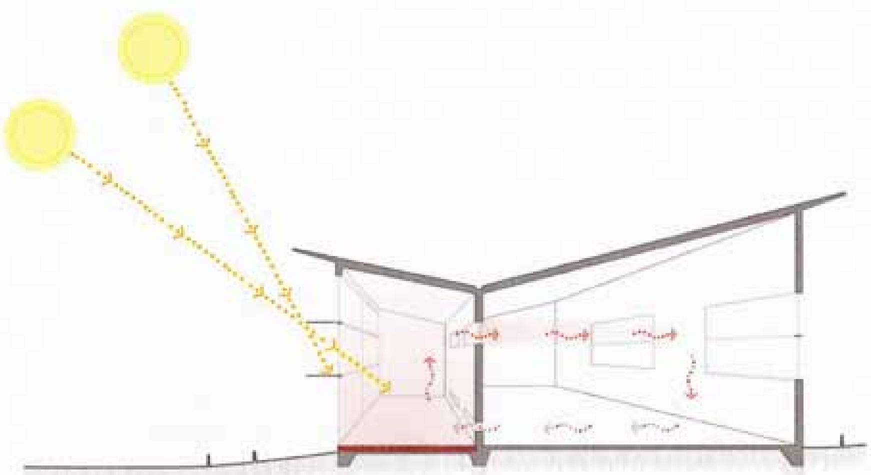


A Direct Gain System uses thermal mas to absorb and store solar energy to heat a building. Shading devices control unwanted summer sun.

Diagrams from the Green Studio Handbook



Schematic Diagram of an Indirect Gain Heating System showing the collection of solar energy in a south-facing thermal storage wall, which then transfers heat into the occupied space.



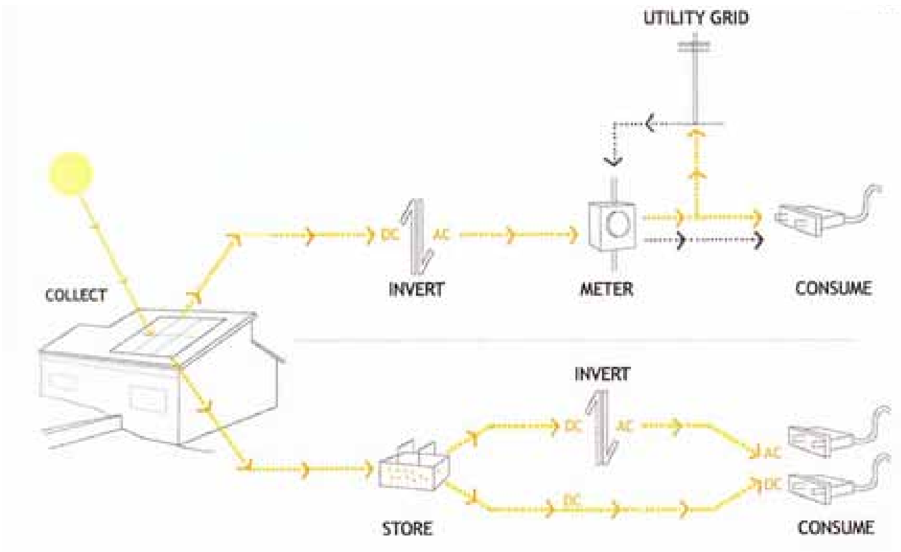
Conceptual diagram of an Isolated Gain passive solar heating system.

Diagrams from the Green Studio Handbook

Another solar radiation technique is called indirect gain. Indirect-gain can be in the form of "a massive assembly (such as a Trombe wall or roof pond) [that] absorbs solar radiation without directly admitting the sun into the occupie[d] space." The heat that collects within the thermal mass then radiates the heat when temperatures decrease, convectively circulating the heat into the space. More specifically, a thermal storage wall is a south-facing glazing that has a thermal storage form (such as, masonry, or water) that is directly located behind the glazing. The solar radiation then penetrates the thermal form through the glazing and warm the element. The heat that is collected in the thermal storage form is conducted through the form, to the surface then radiated into the space. Typically, trombe walls will be designed with vents located at the base and top on the wall to create a stacking effect, enabling ease of convection. Thermal storage ponds or water walls, convective currents in the water wall enable heat transfer to the interior, helping efficiency. Thermal storage walls, roofs or ponds will be most beneficial when designed with the building form. Both direct, and indirect solar gain can be utilized to balance the heat throughout the day.

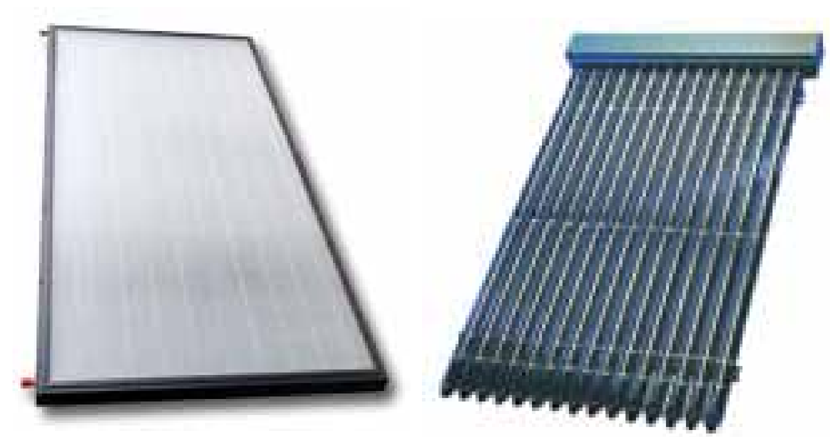
Isolated gain systems passively heats using solar collection from a space that is thermally separated from the living space. The most typical type of an isolated gain system is a sunspace. They essentially work by storing energy that is then redistributed to the occupied spaces throughout the day through natural radiation, conduction, and/or convection. These systems are easily applied to a structure however; they do change the overall appearance of the south facing façade drastically.

Solar energy use has surged, on average, about 20 percent a year over the past 15 years. This means that solar power is an energy resource that is becoming more efficient, has a growing demand that is becoming more affordable, in-turn, reducing the payback period. The growing desire for solar technologies is primarily due to need to reduce rising energy costs while also offering bonus perks such as; using clean energy that does not emit any off-gasses that would contribute to global worming, solar power is 100% renewable, and it is easy to install and maintain. When utilizing PV for autonomous systems and depending on the size of the PV array, it is even possible to make money by selling additional power back to the grid. Autonomous systems are great for an independent approach to powering ones home or building, taking the reliance off of public service systems and reducing the community services infrastructure cost. They do however rely on a typical individual who is willing and able to care properly for the system as needed. District systems however are becoming more common as the broad need for building green and living sustainably increases.



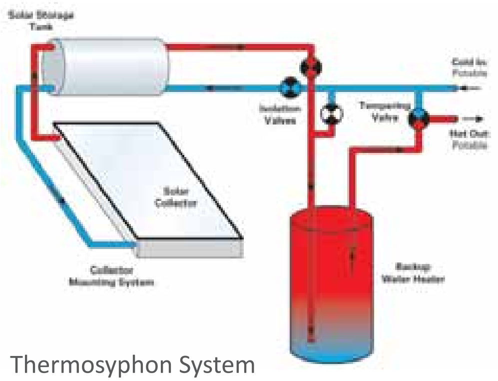
Schematic diagram of Photovoltaic systems; grid-connected (top) and stand-alone (bottom).

Solar Photovoltaic cells are incorporated into panels made of semiconductor materials. When the sun hits the cells, electrons are knocked loose from their atoms. The flow of these cells is what generates energy. The incident solar radiation is therefore converted to energy that can be used to power direct current outputs, can be stored in battery systems, or converted to alternating current to power such loads back to an electrical grid. Stand-alone PV systems usually store excess energy locally and invert the energy needed. Typically, a standard high-power solar module generates 230 Watts and measures about 5.5 feet by 3.5 feet. A 1 kilowatt Solar System requires about 85 square feet of installation area and for a typical family of 4, assuming that the home is built tightly, with passive fenestration, and is no larger than 1,200 sq ft, the home should need roughly 500 sq ft of PVs.

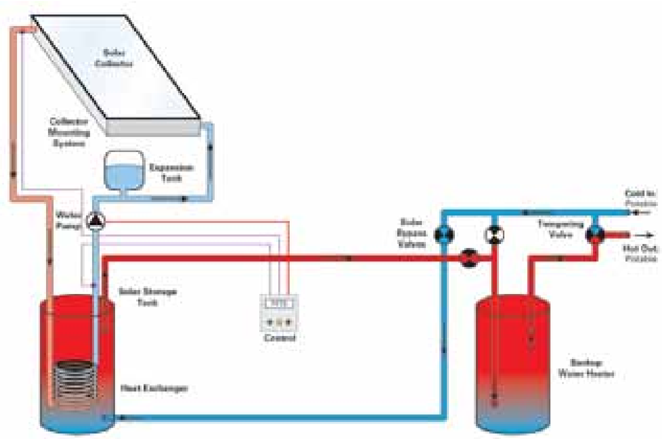


Solar Photovoltaic System & Solar Thermal Evacuated Tube System

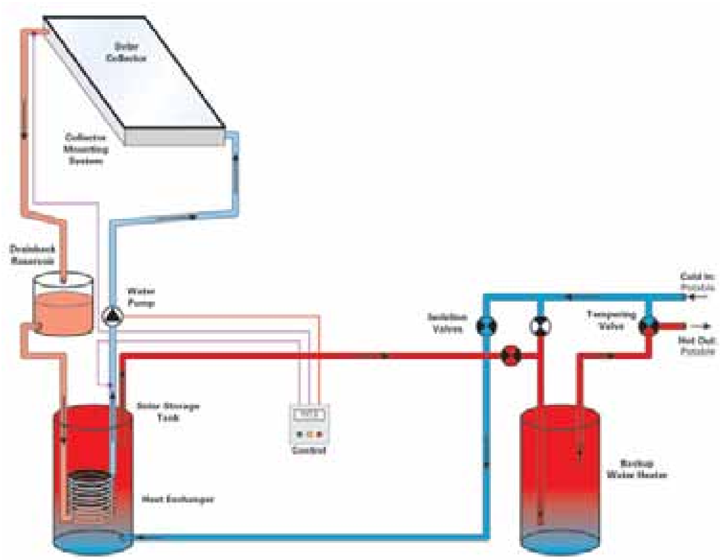
Solar thermal energy systems are used for domestic hot water, pool heating, preheating of ventilation air and/or space heating. The most common use for a solar thermal system is for domestic hot water, which is a large portion of homes energy use. Heating water can account for up to 25 percent of the energy needs in a typical single family home. That means that the water heater is the single most energy consuming appliances in the home therefore investing in a solar thermal system can alleviate the hot water energy expense by 80-90%. Using solar thermal systems for domestic hot water does typically require a back-up heating system but is mainly comprised of the collector plate, a circulation system that moves the heat to storage, a storage tank and a control system. Typically, in colder climates, the thermosyphon systems, pressurized glycol systems and the closed-loop drainback systems are used.



Thermosyphon System



Pressurized Glycol System



Closed-Loop Drainback System

The thermosyphon system is the most common passive system that operates on the principal of heat rising. In colder climates, an antifreeze solution (ie. propylene glycol) is used in the closed solar loop and freeze-tolerant piping that works with the potable water lines in the attic/roof. More specifically, the collector heats water (or antifreeze solution) that causes the fluid to rise by convection to a storage tank. The movement of the fluid is dependent on the temperature of the fluid, which means that this system is most effective with optimal solar radiation.

Pressurized glycol systems are closed loop systems that transports potable water to the solar storage tank. A water and antifreeze solution circulates from the collectors through a piped coil located in the solar tank and then in pumped back through the collectors. The potable water is warmed by heat transfer through contact with the pipe. Such systems require an expansion tank and few other auxiliary components for filling, venting and maintaining the system. This system is unique in that the collectors can be mounted anywhere and are the only option for very cold climates.

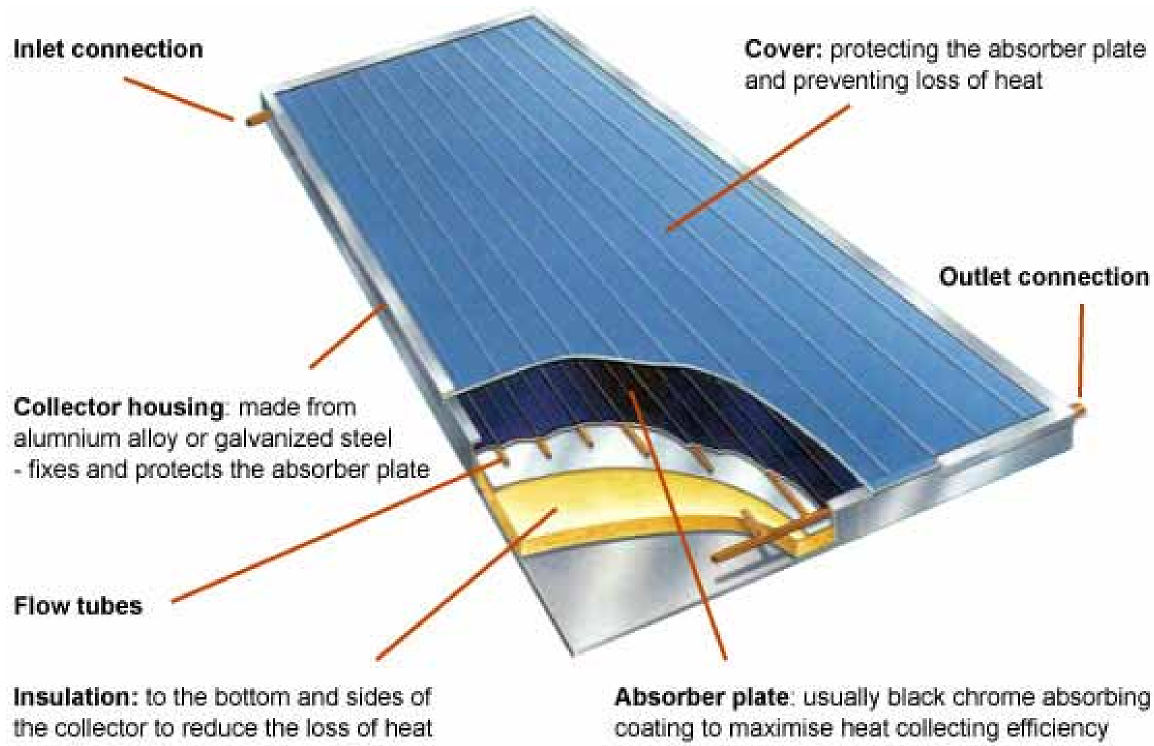
Closed-loop drainback systems offer the least maintenance of the three. The heating transfer fluid is distilled water, rarely needing replenishment. At rest, when the system is not pumping, the solar collector is empty and the distilled water is stored in a reservoir tank typically located above the storage tank. When the pump turns on, the distilled water is circulated from the reservoir back through the collector and heat exchanger, passing heat to the potable water in the solar tank. When the pump shuts off, the distilled water drains back to the reservoir. The collector must therefore always be higher than the storage tank and there must be sufficient continuous slope in the piping to ensure against freezing. These systems are the most reliable in both cold and hot temperatures and rarely need servicing however do require larger pumps and if located in a place where the pipes could potentially freeze, glycol must be added.

The solar thermal collectors that are commonly used are flat plate collectors and evacuated tube collectors. The collectors need to be anywhere from 45 to 90 degrees facing south. Typically sized at 4' x 8', they consist of piping through which water (or a glycol solution) is heated. Typically, the collectors heat the fluid to temperatures between 50°F to 180°F. Generally; when sunny and warm the temperatures range from 140°F to 180°F; when cold and sunny the range is 120°F to 150°F; and when cloudy the temperatures range from 50°F to 90°F. Regardless, if the temperatures from your solar thermal system are greater than the incoming cold water, it's saving you energy.

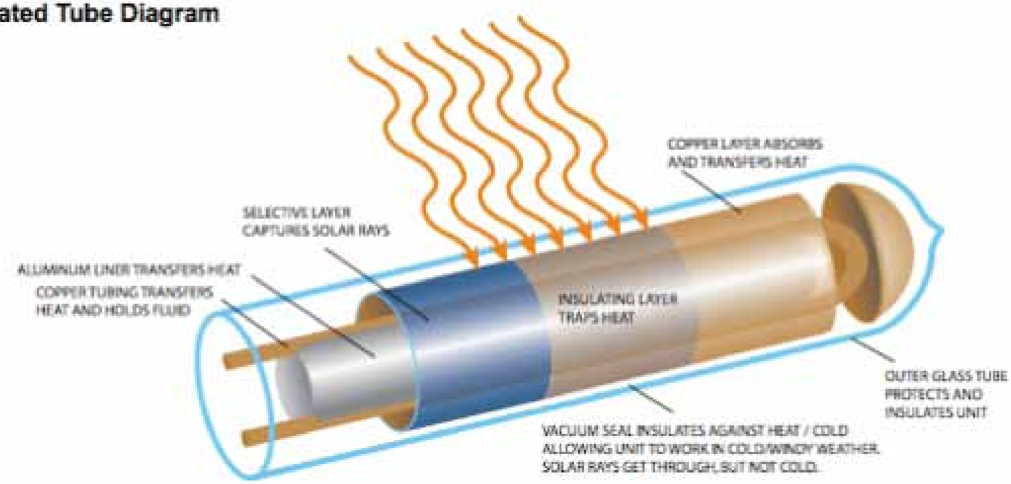
Flat plate collectors are the most common. They are rectilinear, thin and have a transparent or translucent cover. Copper pipes run through the box carrying either the water or antifreeze solution that is warmed by a black absorber plate that holds solar radiation and heats up the fluid which is circulated through with the pump or gravity into the building. Generally, these collectors can be used with every system.

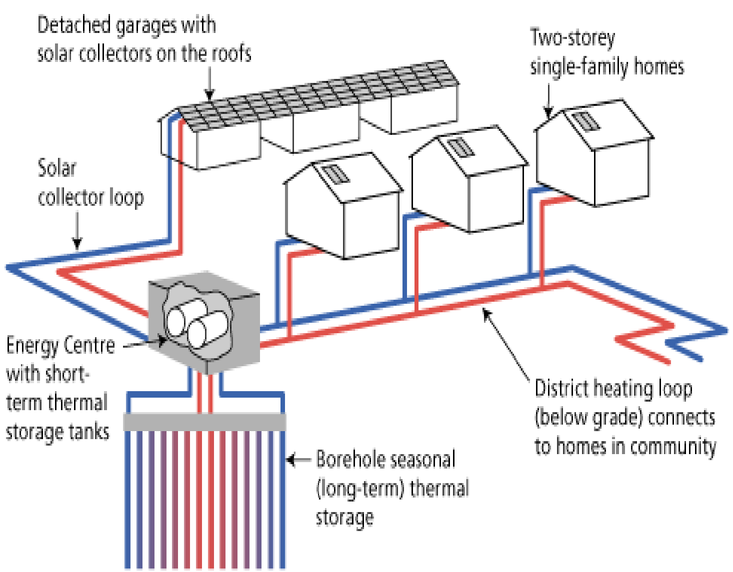
Evacuated tube collectors are more efficient and do not require as intense direct solar gain, performing better than flat-plate collectors in cloudy weather. The collectors are characterized by a series of glass tubes that surround the piping. The piping is coated with an absorber tube that helps to provide high absorption of heat with low emissivity. The solar radiation enters the tubes, hits the absorber and heats the antifreeze fluid. The tubes are vacuum-sealed, helping them to achieve very high temperatures and reduce heat losses. These collectors are generally more expensive however offer a greater payback period than the typical flat plate collector. They can be used with all systems.

Flatplate Collector & Components



Evacuated Tube Diagram





DISTRICT SOLAR ENERGY

District systems are becoming more common as the broad need for building green and living sustainably increases. More specifically and on a much larger scale, "solar thermal power plants employ various techniques to concentrate the sun's energy as a heat source. The heat is then used to boil water to drive a steam turbine that generates electricity in much the same fashion as coal and nuclear power plants, supplying electricity for thousands of people." New developments, such as UMore Park, that are designed around the premise of being net-zero have the greatest potential for successful district solar, however, there are varying results determining the cost effectiveness of developing district systems vs. independent housing systems. Using techniques that allow the built environment to function most efficiently without any renewable power source integrated will significantly reduce the cost of investment of grid PV and utility systems. The cost of construction on homes that meet standards needed to reach net zero may however make it unfeasible to invest in district energy dependent on the climate however, a study in Montréal (having to design for it's heating degree days as Minnesotans do) has concluded that the most cost effective solution is actually to achieve just 50-75% of the passive house standard and then use district system to provide the remaining energy. This technique also helps to adapt the grid size for specific capacities, reducing the amount of additional power and allows the utility services to adapt the PV array size, as the market conditions require. Also, the simplicity of sizing a grid connection system as opposed to a stand-alone system is that there is no need to deal with storage devices or additional output capacity to charge storage within each dwelling. The utility grid provides a place to store excess generation capacity and a source of electrical backup when the on-site PV system cannot provide adequate output. Other benefits include; sustainable resource loops are more easily closed by having location specific treatments and management, synergized management offer greater chance of optimal production meaning greater output for less cost, energy efficiency can be optimized through the initial design of transmission lengths to the source, and makes it easier to design around than having to optimize the projected 13,000 homes plus infrastructure of UMore Park that would need autonomous solar energy to become net-zero.

There are some disadvantages to consider, primarily of smaller-scale integrated district energy systems that operate by utilizing the roof-tops of the district. There is a "perceived increase maintenance cost on a per-dwelling unit per individual service basis compared with conventional segregated service delivery systems" as compared to the interconnected district systems that allow for ease of system control, less production and recycling systems. Also, these layouts would require an intense design scheme made to optimize solar radiation of each structure. Each lot may require more space for the PV systems to gain optimal solar radiation so as not to be located in the shade of any surrounding building or tree. Other limiting constraints remain the budget of PV that can be afforded and the location and space availability of the PV mounting.

OPTIMAL SOLAR LAYOUT

For passive solar as well as solar technologies to operate the most efficiently, they must be integral components within the initial design phase. As mentioned earlier, solar power relies on specific southern facing orientation and optimal 45° angle toward the sun while also being exposed to the sun directly for a large part of the day which in turn affects the orientation and layouts of adjacent structures. The following is a stellar synopsis of a study titled “Design of Solar-Optimized Neighborhoods”.

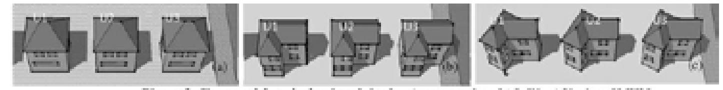


Figure 2. Shapes of detached units of site I: a) rectangular; b) L-W; c) Variant V-W30

A recent study titled “Design of Solar-Optimized Neighborhoods” by Caroline Hachem, Andreas Athienitis and Paul Frazio of the Department of Building, Civil and Environmental Engineering at Concordia University in Montreal Canada, focuses on the parameters that affect solar energy potential. These parameters include building shapes, density within a site and site layout. The objective of the study was to offer up an optimal design of an urban neighborhood that optimized both passive solar heating and daylighting and also solar irradiation for solar technologies.

Figure 3. Site II layouts: a) Rectangular; b) L variants; c) Obtuse-angle

The findings conclude that within the parameters of a pre-determined density, the layout of the site and shape of the structure interact. The rectangular shape that is typically seen as the most efficient for optimal energy efficiency isn’t necessarily the greatest shape for the solar capacity in the site layouts. More specifically, the major factors that need to be considered early in the design phase are building form, orientation, and self-shading effects of south facing façades and roofs. By rotating the form or primary roof for solar collection from true south, solar irradiation is significantly affected. Rotation to the west may increase the façade irradiation by up to 70% and roof building integrated PV electrical generation by up to 25% in the summer months while corresponding reduction for winter is up to 50% and 30% respectively. The study of the L shape and its variations show that different shapes and orientations affect the total exploitable area of roof surfaces for PV integration. By maximizing the south roof area, depending on the floor area and cubic feet needing heating and cooling, can increase the total energy generation by up to 35% annually relative to the shape. Heating and cooling demands are also affected by the shape—the most efficient being the south-facing rectangle while the L-shape variances require around 7-8% more heating demand and is not affected significantly by rotating part or the whole of the shape. The shade that is cast on the east and west façades can have up to a 12% energy demand increase as compared to an isolated unit. Some building configurations, such as the L variant configuration that was situated around a curved road, yields 33% more electricity generation than the rectangular configuration in the same layout. Also, the heating energy demand for the L variant configuration in only 5% higher than the rectangular configuration. Another important note to mention is that the electrical generation relies on peak generation time, therefore the site layout and roof orientation is important. Shifting the peak generation time toward the peak demand time for the PV systems can lower the net energy cost and also reduce net peak demand from the grid.

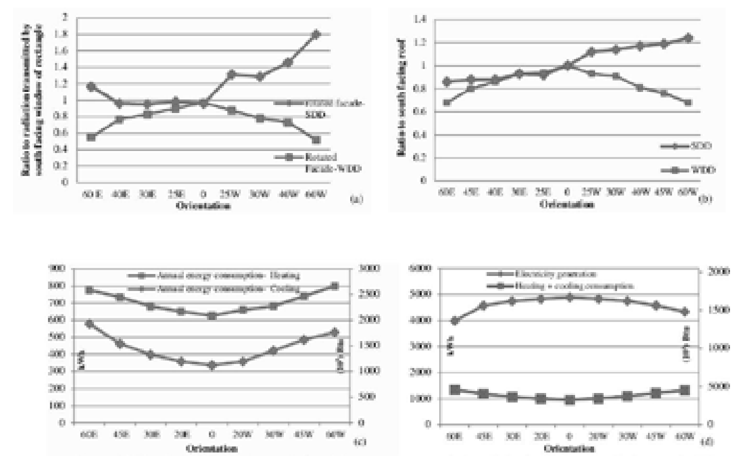


Figure 4. Effect of orientation on a) transmitted radiation over a summer and winter design day, b) energy production over the SDD and the WDD, c) Annual heating and cooling, d) comparison of energy production and total energy use.

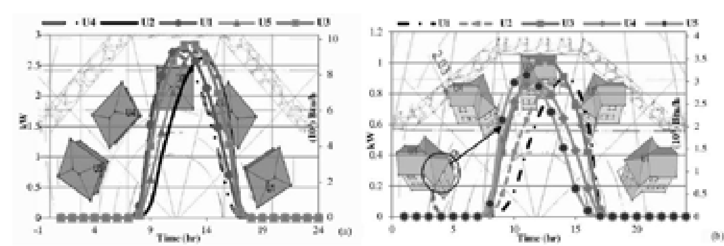
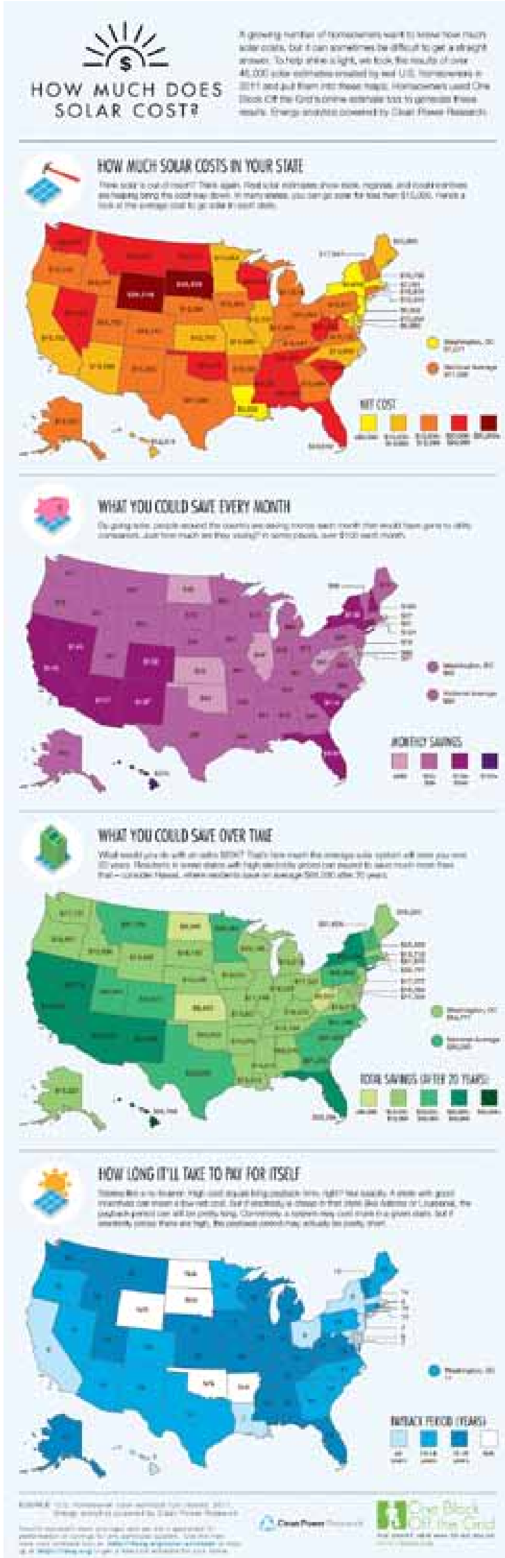


Figure 7. Hourly electricity generation (kW and Btu/h) for site II: a) on the total south roof rectangular WDD; b) on the hip roof of L variants WDD



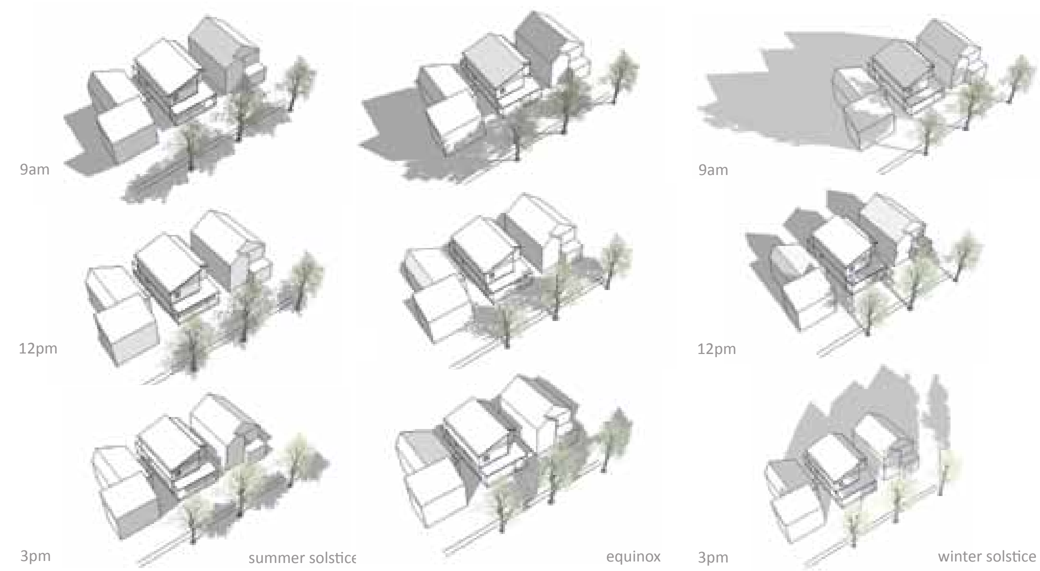
PAYBACK & STATE INCENTIVES

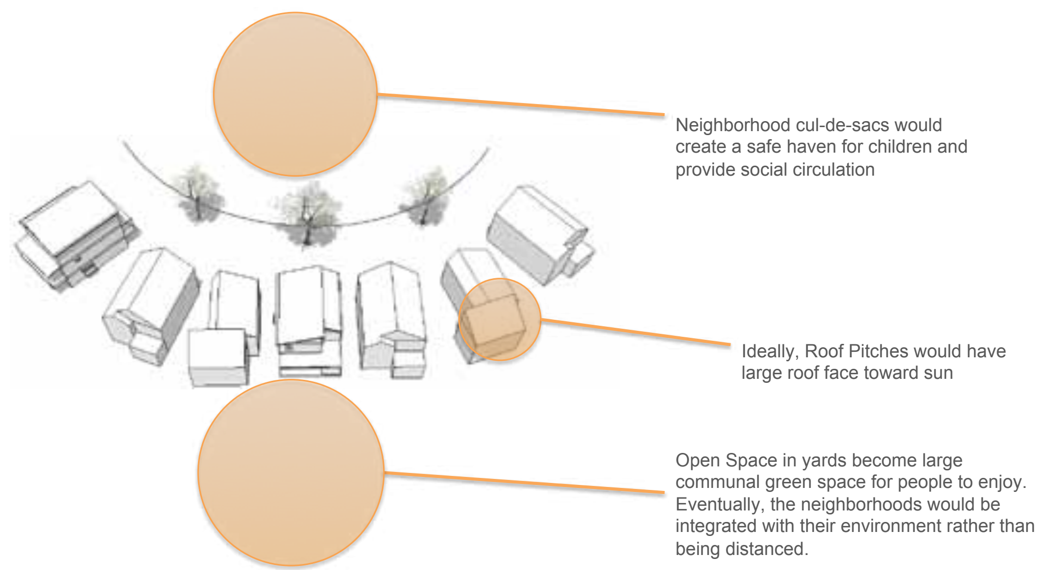
Integrating solar design whether passively or through PV systems is a substantial up-front cost. The building is designed with this in mind much earlier than typical structures, require bulkier wall and insulation systems for efficiency and obviously the cost of the PV system itself. The cost however is certainly manageable when taking advantage of state subsidies like tax credits, utility rebates, etc. to minimize the system cost. These costs vary but can have a 10 to 30 year payback on a typical, non-subsidized system however recent studies suggest an energy payback of about 3-4 years is much less than the monetary payback period.

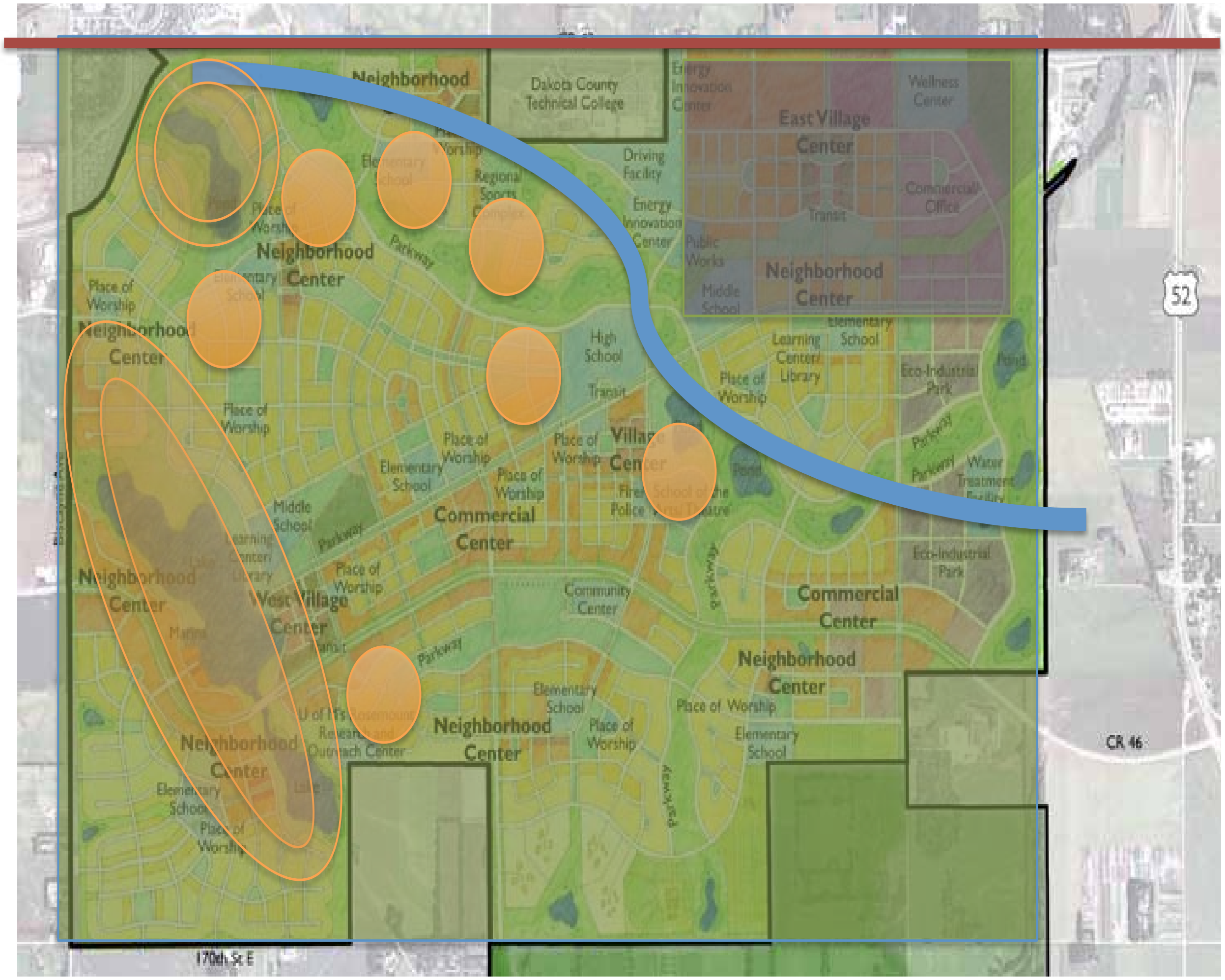
Fortunately, in Minnesota, the statewide leadership in environmental advocacy has helped to drive the engagement of the Solar America Cities Program, as well as the renewable energy standards of the Next Generation Energy Initiative to help fund specific solar initiatives in the form of incentive programs, utility rebates, utility loans and utility incentives. Residents in particular can gain payments through particular utility companies based on the amount of energy produced by the applied PV system. Also, the PV Rebate Program funded by Xcel Energy, helps to absorb some of the up-front PV costs that are connected to the grid. These rebates run anywhere from $2 per Watt DC up to $20,000 per system when connected to the grid. Net metering is also available on PV up to a 40kW capacity meaning, the utility company will compensate for net excess generation at the same rate that electricity is charged. Also, purchasing a solar installation exempts it from the state sales tax.

UMORE PARK RECOMMENDATIONS AND CONCLUSION

UMore Park is on a direct path to promote sustainable living. In doing so, the investment in renewable resources like solar will allow the community to live off the grid without having to give up our current day necessities. Needing to design a community built for 20,000 to 30,000 people, renewable energy will be an integral component in the way the community functions. Solar power is just one viable option however it is a powerful one. The modern day awareness of sustainability will become a basis from which we live in the future. It is important that techniques used for building sustainably are integrated into the framework of the community development. Solar efficiency is optimized when assembled form the earliest stages of design balancing the energy generation and energy consumption. Designing buildings and dwellings integrating passive and technological solar power need to integrate building form and orientation from its conception along with simultaneously designing tight and beefy envelopes will maintain its thermal integrity and lessen the need for artificial heating and cooling. The need for Solar PV for a well built, 1,200 square foot home should need roughly 500 square feet of PV panels. These panels should be oriented south at an angle of 45° and depend highly on the building form and orientation. Solar Thermal systems will help to alleviate nearly 25% of the energy needs of a typical single family home. These systems are most efficient when near 90° facing due south. Autonomous solar power is an empowering lifestyle, bringing one close to living off the gird however; it may be most beneficial for UMore Park to invest in small district solar plants. Independent district solar will generate power for more individuals while allowing for ease of function, utility, and maintenance while reassuring that there is enough solar generation for the community as it is easily retrofitted for the needs. This would also alleviate the pressure of the solar designed neighborhood lay-out—however, integrating district solar may also be an option. This option would be a positive approach to aiding the community involvement toward living sustainably through the direct connection to the panel on the dwelling. By simply having a view of the PV array, the neighborhood will have a heightened sense that communities must grow together to maintain a healthy lifestyle and planet.







As the community evolves, sustainable techniques and technologies will evolve bringing changes to district & neighborhood characteristics. The progressive changes of UMore will bring pods of generational renewable energy forms and functions. Instead of the more traditional approach of community design the master plan currently embodies, one can imagine that the existing main circulation will form the main center and neighborhoods will form around natural amenities such as lakes, streams and nature parks. These neighborhoods will be a direct expression of sustainable design as it grows, while maintaining the ancient optimal passive design techniques. The neighborhood-optimized forms would be based around arching streetscapes and circular cul-de-sacs that promotes natural solar heat gain, passive breezeway patterns and also generates larger green spaces in-between lots.

It's true, we could satisfy all of the world's energy needs for an entire year if we could capture just one hour of the sun's energy. With the current land at the UMore site, solar power is the greatest option for renewable resources. It has the potential to be entirely designed around the optimization of both passive solar and solar technologies.

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