

## WATER HEATING AND CONSERVATION

1. Hot water from evacuated-tube, solar, hot-water heater and 80-gallon storage tank with feed to on-demand electric tankless hot water heater with capacity of 2 gallons per minute. About 50% of the energy for hot water is supplied by the sun.
2. Low-flow shower heads (1.5 gpm), low-flow bathroom faucet

- aerators (0.5 gpm), and low-flow toilets (dual flush, 1.6 and 0.8 g per flush) substantially reduce water use and the amount of hot water needed.
3. 1,875 gallon cistern filled from roof runoff for watering garden and plants with overflow to pond.

## INDOOR AIR QUALITY

1. Energy Recovery Ventilation (ERV) unit for fresh air is integrated with heat-pump and air circulation that is controlled by a programmable timer. Air can be circulated within house, or with outside air, with and without heating/cooling provided by heat pump. The ERV

- allows for the incoming fresh air to be heated or cooled by exiting air.
2. Exhaust fans in bathrooms remove excessive moisture.
3. High quality filters on geothermal heat pump and ERV clean air.

## ELECTRICAL

1. Electricity is from a 3.12 kW system with an annual production of 3,250 kWh. In the first year, annual use was 2,400 kWh with 850 kWh fed to grid. Oberlin Municipal Light and Power System has net metering that allows Trail Magic to feed excess electricity onto the grid and to take electricity from grid when needed. At this time Trail Magic does not have a battery backup system. If the grid

- goes down, the PV system shuts down and does not supply power to the house.
2. Energy Star appliances throughout and icebox in kitchenette.
3. Compact fluorescent and LED lighting.
4. Day-lighting from window placement replaces the need for electric lighting in daylight hours.

## HEATING AND COOLING



1. Pond geothermal heat exchange – 2 ton unit with 3 ton loop (4:1 efficiency ratio—4 BTUs of heating/cooling for each BTU used). If wood stove is not used, then annual energy for heating and cooling with geothermal heat pump is ~1,900 kWh.
2. ERV (energy recovery ventilation) unit.
3. Passive solar gain is determined by proper orientation, size, and shading of windows.
4. Windows and stairwell placed for passive cooling and ventilation, the predominant cooling mode.
5. Airtight wood stove fueled by wood from site trees provides heat on cold, cloudy days.

**Note:** Trail Magic has a “Cadillac” heating/cooling system that is not only highly efficient but also provides for superior indoor air quality, mold elimination, and occupant comfort and health. Design strategy allows owners to heat and cool house passively and with wood stove, using mechanical systems only as needed.

Above: South and western façades show most windows on south façade. PV panels are on west side of south roof and evacuated-tubes of hot-water system are on east side. Deck faces west and in foreground, out of sight, is the below-grade, south-facing sun patio.

# Trail Magic

A climate-neutral, positive-energy home in which body, mind, and spirit flourish and our lifestyle of simplicity and interdependent self-reliance find expression as we live, work, and prosper among a community of kindred spirits.

### RESIDENCE OF:

Carl and Mary McDaniel  
495 East College St.  
Oberlin, OH 44074

### ARCHITECTS:

**Schematic Design:**  
Donald Watson, FAIA  
EarthRise  
Trumbull, CT  
(203) 459-0332  
EarthRise001@  
SBCglobal.net

### Execution & Construction:

Joseph Ferut &  
Associates, Architects  
Elyria, OH  
(440) 323-9930  
joe@ferutarch.com

### BUILDER:

Michael Strehle  
All Seasons Builders  
Lorain County, OH  
(440) 574-1231

### SOLAR CONSULTANT:

David Borton  
Solar Age Technologies  
Troy, NY  
bortond@rpi.edu

### COST:

The cost for house alone was \$146 per square foot.



Joseph Ferut

## SITE

1. Less than one mile from downtown Oberlin with easy access to a host of in-town amenities, as well as city water and sewer.
2. Four acres: mixed woods and field.
3. House located to orient long wall to true south for passive and active solar and close to road to preserve majority of site.
4. Self-maintaining landscape with any needed water from cistern and pond.
5. A walk-out, south-side patio is sun exposed and wind protected, thereby extending the season of outdoor activity and plant growth.
6. Pond dug to provide fill for house site, geothermal heat source/sink, and fish for food.
7. Quarter-acre garden and acre field for mulch.
8. Two derelict houses removed with 150 tons recycled (59%).
9. Existing gravel driveway extended to conserve resources.

## HOUSE

Two-and-a-half stories with lower floor earth-bermed on three sides; 2,494 square feet.

**Ground Floor:** Two bedrooms, full bath, family room, kitchenette, mechanical room, workroom, under-deck storage area. This floor was designed to accommodate guests.

**First Floor:** Living/dining room, kitchen, pantry, half bath, master bedroom, walk-in closet, full bath, deck.

**Half Floor:** North side study and library-loft area

overlooking master bedroom.

**Stairwell:** Ventilation windows at high and low points along with stairway are designed as a wind tower to ventilate house in warm months.

The lower floor is a summer refuge, naturally cooler due to thermal mass and earth berming. Adjustable shades passively prevent overheating during the day and heat loss at night.

**Detached Barn:** Space for truck, car, and tractor with large, multi-purpose, second floor room.

## ENERGY USE SUMMARY

Trail Magic annually uses 60 million BTU. One-hundred percent of this energy is provided on site by sun: daylighting and passive solar gain from the winter sun, 32 million BTU; wood stove, 15 million BTU; PV panels, 11 million BTU; and solar hot-water heater, 2 million BTU.

**Note:** Over half of this energy results from passive solar design. The cost of passive solar features—window placement and envelope—was \$16,000, or less than 5 percent of construction cost when compared to conventional construction and with a payback of 5 to 10 years.

## ENERGY COST

In 2005 the average, single-family home in the U.S. purchased annually 107 million BTUs for ~\$2,100 (DOE). Energy cost for Trail Magic's first year was zero. It runs on its own sunshine.

*Design and layout: Kelly Viancourt, photos: Joseph Ferut and Carl McDaniel, text: Carl McDaniel, Donald Watson, Joseph Ferut, Mike Strehle*

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Joseph Ferut

## CONSTRUCTION

1. Ground Floor: Reddi-Wall insulated concrete forms with additional 2.5 inches of wet-spray cellulose insulation (half below ground, walls 13 inches thick, R = 35.5) and 4 inches rigid insulation under cement floor (R = 20).
2. First Floor: Double, 2 x 4 wall with 1 inch spray foam air barrier and 10 inches wet-spray cellulose insulation (R = 47.5). Double wall construction reduces "thermal bridging" (the movement of heat through wall), thereby increasing effective R-value.
3. Siding: Prefinished fiber-cement "Hardiboard" siding and trim, used for its durability, fire resistance, and low maintenance.
4. Roof: TJI rafters with 1 inch spray foam air barrier and 15 inches wet-spray cellulose insulation (R-value = 62.5); 24-gauge, standing-seam, steel roof with light color that meets Energy Star requirements for high heat reflectance.
5. Windows: Loewen high performance

windows—double- and triple-pane low-E argon with warm edge spacers.

South windows tuned for solar gain.

6. Finishes: Low volatile organic chemical paints; recycled ceramic tile; wood stove hearth made from reused granite cobblestones; local and on-site trees lumbered for flooring, shelving, pantry countertop, interior and exterior beams.

7. Framing Strategies: Engineered rafters and joists are used in lieu of large dimensional lumber, which comes from old growth forests. Nothing larger than a 2 x 6 is used in construction. Advanced framing techniques are used which minimize amount of lumber needed without sacrificing structural integrity.

8. Airtight construction: Use of spray foam air barrier, caulk and seal package, high quality windows, and results from a blower door test substantially reduced air infiltration, which is a significant factor in heating and cooling loads.

## CONSTRUCTION WASTE: 95% reused or recycled

1. 10,475 pounds of waste generated:

*Wood:* 4,271 lbs. [wood scrapes reused as wood stove kindling or for children's play blocks, OSB and TJI recycled off site as ground mulch.

*Sheetrock and plaster:* 3,910 lbs. [all recycled on site by rototilling into soil]

*Hardiboard:* 780 lbs. [crushed and used

as base for driveway]

*Cardboard:* 756 lbs. [recycled]

*Metal:* 181 lbs. [recycled]

*Plastic:* 66 lbs. [recycled]

2. Landfill: 511 lbs. [soiled paper and rags, pressure-treated and painted wood, non-recyclable plastic]

3. Reused and Recycled: 9,964 lbs.



Carl McDaniel



Joseph Ferut



Joseph Ferut



Joseph Ferut

(Photos, clockwise, from upper left) 1. Bookcases on stairway wall going to second-floor study and loft. Wood for bookcases from on-site ash, black walnut, maple, and red oak trees. 2. Daylighting through open risers on stairway from first floor to second floor and wood bin behind stove in living-dining room on winter day. 3. Solar heating and daylighting in living-dining room on winter day. 4. Kitchen, kitchen beam from on site ash tree, and one of two sunset windows on summer day.

## CHALLENGES AND CHOICES

We employed systems thinking and holistic design decisions to resolve conflicts that arose from the individual perspectives of architecture, beauty and aesthetics, building standards and codes, economics, energy and resource use, and environmentally-appropriate construction.

Design and material decisions rarely have one optimal choice but rather a preferred choice within the context of the particular project. Our overriding metric, however, was the lifecycle cost measured environmentally and economically.

Our behaviors were, and continue to be, critical in making Trail Magic a *climate-neutral* [production of operating energy results in no net-release of heat-trapping gasses], *energy-positive* [more energy comes from on-site production than used] home. We strive with varying degrees of success to use energy and resources only as required for the task at hand.