SECTION 5

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Critical Look into ®ISOMAX (Zero Energy Use Structures) Construction

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Abstract:

The intention of this paper is to discuss the opportunities of implementing in the ®ISOMAX Building Technology (Unknown, 2012 1) as a means to achieving Zero Energy Use Structures. ®ISOMAX is a fully integrated building system that collects solar heat energy and stores the heat in the earth just under the building. The system uses circulating fluid to transfer heat between the earth storage and the building envelope. The process allows the entire envelope of the building to take advantage of the collected energy by running the fluid, warmed or cooled, to move heat into or out of the insulated concrete wall and the roof. As Energy Reconsidered continues to prepare this technology for introduction into the American marketplace the team is engaging in dialogue with the construction industry to gather support for advanced modeling and prototype testing opportunities.

Summary:

The ®ISOMAX Building Technology as a whole furthers the notion of living building (Unknown, 2012 1) standards by integrating the building shell and conditioning components into an active system that can store or collect energy in response to the exterior weather conditions and the internal comfort levels of the occupants. The building shell becomes an active participant in occupant comfort and energy savings.

In the European market, this type of building construction has delivered an average heating load of approximately 24 kWh / (m^2/a) (Sturm, 2009) which is just above those of a passive house standards that have set the most restrictive benchmarks for the heating and cooling load of a structure not to exceed 15 kWh/(m^2/a) (Passive House, 2012)

The ®ISOMAX building system relies on two ideas that are different than those currently being used in a high performance buildings or passive house standards (Passive House, 2012 4)The first concept is the transformation of the exterior wall from a passive thermal resistance to one that can actively participate in the temperature control of the interior. This is accomplished by the heat transfer fluid which moves heat into and out of the walls and roof. The roof captures the naturally occurring solar heat energy for storage in the earth. The second concept is to utilize the earth as a thermal medium to provide cooling, heating, and storage to allow for temperature regulation of the building. The structure interacts with the earth-stored energy, allowing it to be stored and recalled as needed over time.

Introduction:

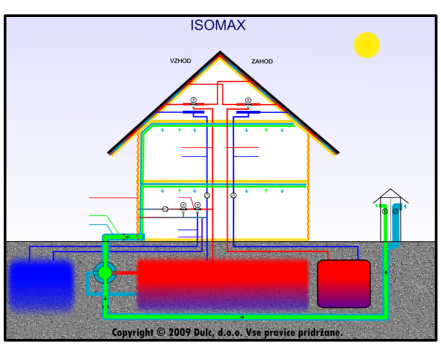
Several operational case studies have been built by international license partners, with the design guidance of Dipl.- Ing., Phys. Edmond D. Krecke. The previous case studies looked at the local european building technology to validate this construction approach as well as to engage the European research community to assist with further refinement in construction methods and further support the energy modeling of an active wall system. The European residential and small commercial building practices are different from US practices, and further proof of concept testing is needed to confirm the ISOMAX application in the USA.

Approach:

Our approach begins with a comparison of the performance of an ®ISOMAX home constructed in Slovenia by our international partners with a simulated home located in Philadelphia PA following PASSIV house guidelines (Passive House, 2012 4)The home was simulated using REM/Rate V13.0 (Rem Rate, 2012 5)software commonly used in residential applications to develop energy benchmarking in new and existing construction.

Slovenian Case Study:

The Slovenia case study home is a 170 m^2 size constructed about 100 km southeast of Ljubljana Slovenia and utilizes ®ISOMAX technologies as its only source of heating, cooling, and ventilation. The home is built with ICF exterior walls (U=.145) and standard wood framed roof with high insulation levels (U=.113). The walls and roof are energized using the ISOMAX system to create a thermal barrier between the interior conditioned spaces and the exterior unconditioned space. The home is built on an insulated concrete slab (U=.176). The system has a calculated total energy load of 61 kWh / (m^2/a) with an occupancy load of 4 people (Sturm, 2009)



This case study house is actively monitored and live data feeds can be seen via a web portal contact our office for further assistance as this information is proprietary to our Slovenian partners.

Philadelphia Simulation Data:

For our comparative data we have modeled a typical colonial style home employing passive house standards. In our model we simulated the weather conditions of the home in the Philadelphia, PA area. The house has 190 m^2 floor area and assumed an occupancy load of 4 persons. The exterior wall structure used insulated concrete forms (Berg, 2012) and included semi-conditioned crawl space and attic to house the mechanical equipment. As expected, the passive house based design performed well.

The Philadelphia house simulation model consisted of the following design components. The above ground-wall construction uses insulated concrete form consisting of 2 ½" extruded polystyrene, 6" concrete mass, and 2 ½" extruded polystyrene (Unknown, 2012 8) for an effective U = 0.210. The roof assembly has an effective U = 0.193. There is a sealed crawl space with insulated foundation walls throughout the entire footprint of the building. Both the attic and the crawl space are considered semi-conditioned space for the housing of the mechanical systems of the home. The simulated home has higher U values; however it is located in a milder climate.

Without the introduction of any alternative energy sources such as solar hot water, geothermal ground loops, or photovoltaic electricity the model required a total energy load of 562 kWh / (m^2/a) (Berg, 2012) which is comparable to that of the home in Slovenia.

The total heating and cooling load for the modeled house (16.4) (Berg, 2012) is lower than the Slovenian house (24.0) (Sturm, 2009) This is attributed to the milder climate in Philadelphia. The next challenge is to confirm that an ISOMAX building shell can regulate interior temperature given the local solar energy density and climate.

Table 1. Data Comparison Chart (including Passive House):

Description	Slovenia	Philadelphia	passive
Size m^2	170	190	100-120 ~
Air Tightness	0.6 ACH_{50}	0.6 ACH_{50}	0.6 ACH_{50}
U Wall (W/m^2K)	0.145	0.210	0.2-0.15
U Attic (W/m^2K)	0.113	0.193	0.2-0.15
U Floor (W/m^2K)	0.176	0.403	no requirement
U Windows (W/m^2K)	0.510	0.790	0.790
Ventilation Efficiency	98%	≥ 75% @.35 Wh/m^3	≥ 75% @.45 Wh/m^3
Total Primary Energy: $kWh/m^2/yr$	61.0	57.2	120
Total Heating /Cooling: $kWh/m^2/yr$	24.0	16.4	15

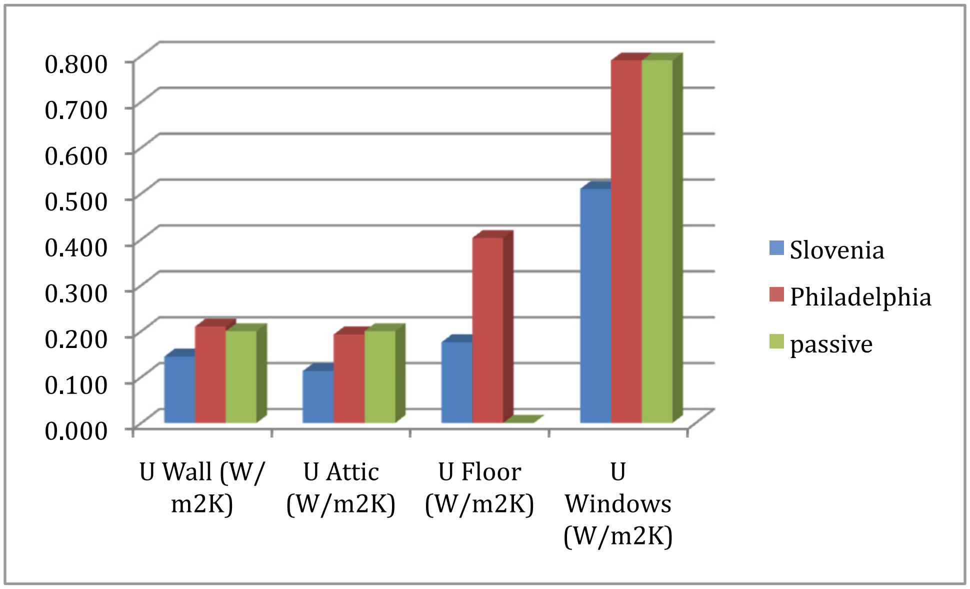


Figure 2. Chart comparing U-Values of Building Components

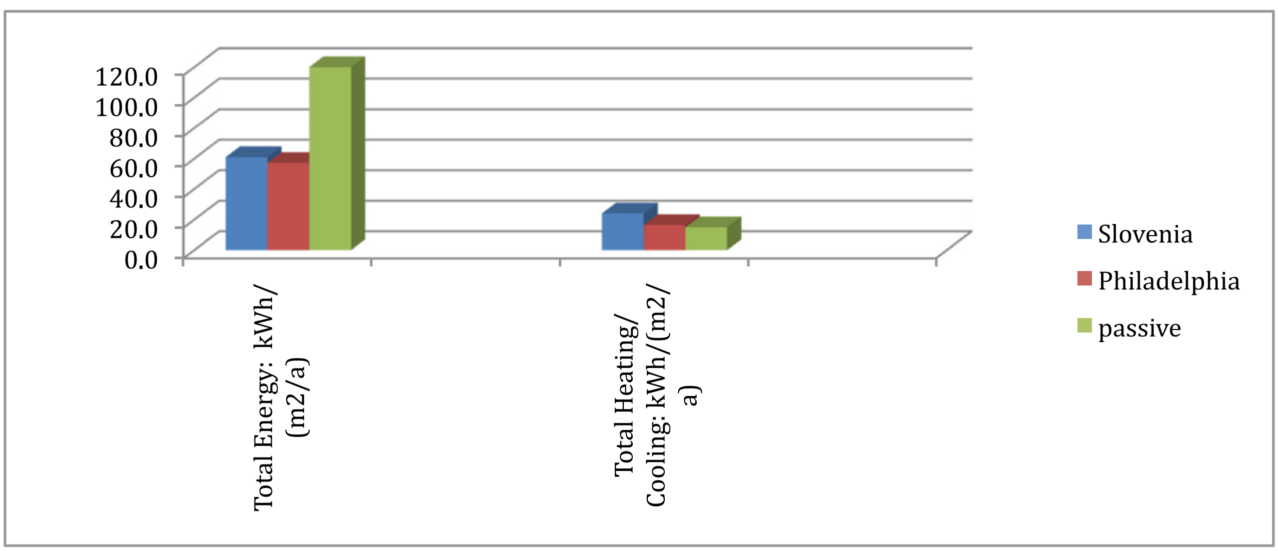


Figure 3. Chart comparing Energy consumption

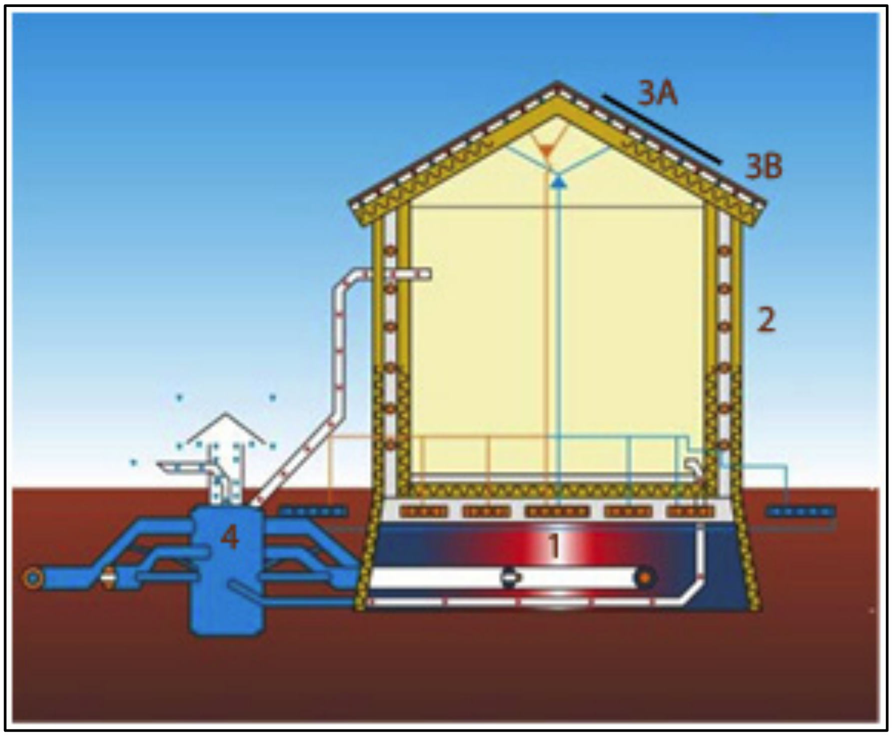


Figure 4: Conceptual Diagram of the Thermal Barrier

Figure 4: Notes
1. Underground storage system layout (energy reservoir)
2. Outer wall design with temperature barrier
3a. Solar Thermal Collection Panels
3b (Low Tech Alternative) Roof structure with solar absorbers
3. Pipe in pipe – ventilation

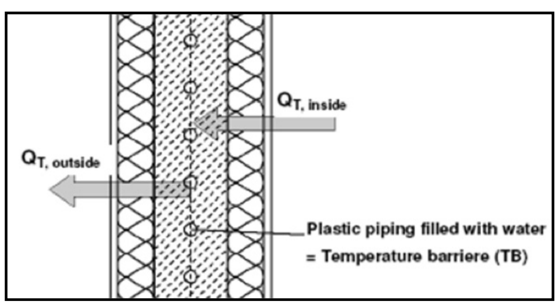


Figure 5: Science behind the Thermal Barrier

Figure 5: Notes
This diagram is the schematic diagram that we are looking to investigate in both a new construction and adaptive reuse condition. In the adaptive reuse setting we have a several alternative construction details. The primary scientific principle is to maintain the thermal mass of the internal wall and foam on each side to maintain a microclimate in the building envelope.

Evaluation Conclusions:

Overall the Philadelphia simulation was aligned with the performance of the case study home constructed in Slovenia. By looking at the data what became evident is that to some extend how to begin to understand the overall effectiveness of the ®ISOMAX system. During this evaluation we focused on the energy budget from four perspectives and using two of these sets of data derive a few conclusions help us understand the effectiveness of the ®ISOMAX system.

We determined there were four separate budgets that need to be analyzed.

- The first was an energy budget connected to the amount of energy that would be used to maintain the thermal mass of the envelope at a constant 68 F/20C.
- The second was the amount of energy storage needed to ensure the system is able to maintain the desired comfort levels and energy performance.
- The third item we need to look at further is the financial investment required to construct a home to these standards in the United States market.
- The fourth and final performance metric is the operating cost of to maintain this type of Zero Energy Use Structure.

When considering the first two "energy budgets" we look at the ISOMAX components integrated into a specific building envelope and building site. The energy required to heat / cool the thermal barrier and the ability for the soil below the building to store the energy required to maintain the thermal barriers constant temperature of 68 F/20C. Although not directly discovered within our energy model a partial confirmation has derived by the similarity in energy loads required by the house constructed in Slovenia and those by the simulated house located in Philadelphia. If we translate the information from our energy model the house located in Philadelphia will be required to capture, store and release approximately 16.4 kWh/(m^2/a) annually to maintain its temperature requirements. When modeled in the simulation the Philadelphia based house required 300 sqft / 500 gallon water heating system and an auxiliary 450 sqft / 6 kWh photovoltaic systems to balance out the energy demands, therefore, achieving a net zero energy use building.

Can a reasonably sized earth heat reservoir store the required energy? Additional questions also arise on the dynamic behavior of the system; can it moderate the heat transfer to maintain internal comfort levels without supplemental heating or cooling systems?

At this point we need specific building performance measures in a US climate zone to understand the local potentials for solar energy collection and the effectiveness of the ®ISOMAX techniques when implemented with our available building methods, materials, and controls.

Current Market Technology:

Despite the invention and integration of new and improved solar / geothermal technologies, conventional building design and construction (with or without these technologies) continues to address building design and energy design (efficiency) as separate non-engaging entities which consist of a static isolated shell and supporting mechanical components. While conventional practices include the installation of high performance / low energy consumption (Energy Star rated) equipment, triple insulated glazing, and super insulated perimeters, Energy Reconsidered's technology shifts this paradigm by transforming the envelope of the building into a computer monitored responsive barrier capable of maintaining a constant interior temperature regardless of the time of year or geographical location, therefore the technology reduces the size and cost of the PV inputs needed to achieve net zero.

Energy Reconsidered's (ER) technology has the ability to be a front runner in the energy technology industry given the current energy criteria being met in the market place today. ®ISOMAX has the ability to easily create Zero Energy Building (ZEB). This is significant because of the 31,800 LEED (Tweed, 2012) certified structures in the United States, only 60 of these meet ZEB or ZEC (Zero Energy Capable) requirements (Tweed, 2012). There is tremendous opportunity in the development and testing of dynamic building assemblies. Additionally, we can design a structure that has a provides us a greater ability to interface with the structure itself while maintaining connectivity to the naturally occurring solar irradiation and thermal storage capacity of the earth. This unique combination if proven will provide a new direction in the building industry and allow for Zero Energy Use Structures to become a standard where as they are currently a rare occurrence.

These investigations are important because it shifts the current construction methodology significantly by integrating a temperature control system into an envelope of a building, then providing an interface for the envelop into the earth and solar collectors, which allow for the collection and reuse of the solar energy. Increasing the ability of a building to reach energy neutrality while greatly reduces its supplemental energy loads is highly likely through the proper refinements of the ®ISOMAX system. Thus enabling a building's envelope to distribute natural energy collected (and stored) from the sun and earth, ER's technology substantially reducing the temperature fluctuations (ΔT) which occur between the interior and exterior surfaces of a building's envelope (wall), maximizes the thermal efficiency of the building, eliminates traditional mechanical equipment and its energy requirement, and greatly reduces the consumption of supplemental and off-site produced energy. This provides the potential for a highly responsive and energy efficient system to rely on for the construction of Zero Energy Use Structures.

Final Conclusion:

Because 95% of existing buildings in North America are three stories or less, which is a design limitation currently seen with ®ISOMAX [(1)] and because it is widely believed that forthcoming changes to National Building and National Energy Codes will greatly affect the minimum standards for new and existing buildings. It is our belief that it is time to reconsider the way buildings are constructed – especially with respect to energy efficiency and dependency. Energy Reconsidered's technology is significant because it transforms the way we build and energize our buildings. We strongly believe that implementing this and other technologies into the marketplace along with sustained research and development is critical to the progress of the building industry. Through this and other research into building materials and systems we will produce more flexible, universal, and cost effective dynamic wall, floor, and roof systems allowing us as a whole to further advance the science of dynamic construction assemblies.

Acknowledgement:

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