The GEOS Town Square: a "percolation park" that is multi-functional as public space, and is surrounded by vertical mixed-use.

A Case Study in Patterns for Sustainable Urbanism

The GEOS Net-Zero Energy Neighborhood

by Michael Tavel

Abstract

The GEOS Net-Zero Energy Neighborhood, breaking ground this winter in Arvada, Colorado, is anticipated to be the largest net-zero energy, urban mixed-use neighborhood in the United States. On-site generated earth and sun power will completely offset the community's energy needs, and replace all fossil fuels. The neighborhood plan is compact and urban. Into this fabric, innovative sustainability patterns, typologies, and systems are deeply interwoven with classic town planning components.

A winner of a 2009 National Honor Award for Analysis and Planning from the American Society of Landscape Architects, GEOS is notable for its symbiotic relationships between urban design, architecture, and landscape that occur at all scales. Stormwater is integrated and omnipresent within the neighborhood layout. The town plan is intertwined with natural systems, stormwater fed landscapes, and civic places. Rain and snow melt feed street tree rain gardens, fruit tree terraces, percolation parks, plazas, and community gardens.

Passive solar orientation is optimized with urban density via carefully selected Building/Lot/Block types, reducing building energy demands by one third. High performance, "passive house" building envelopes reduce energy demands by another third. The buildings therefore need only one third of a mechanical system. This is provided via a heat recovery ventilator in lieu of a furnace. The buildings' energy consumption is, as a result, small enough to be offset by rooftop photovoltaic panels, ground source loop fields, and solar thermal panels.

At all scales, the GEOS town plan aims to foster bio-civic relationships with natural processes, neighborhood ecology, and environmental stewardship. Drainage, agriculture, and sun are coordinated with a diverse network of private and public outdoor space. The GEOS Neighborhood is a relevant case study for sustainability patterns in design – patterns at the neighborhood scale, and patterns at the scale of human experience in landscapes and buildings.

Program and Process

The GEOS Neighborhood is the brainchild of Norbert Klebl. Mr. Klebl, an Austrian living in the U.S., was trained as a petroleum engineer and led a successful career as an international management consultant guiding industries to survive in a changing world. His goal with GEOS was to build a demonstration project that would help to improve resource conservation in the American homebuilding industry. For this he hired the collaborative design team of Michael Tavel Architects and David Kahn Studio.

The site is on industrial-zoned, platted, and graded land that is adjacent to a regional greenway, and located in the midst of western Arvada, Colorado. Arvada is an historic town that grew into a large Denver suburb during the 1960s, 70s, and 80s. In its comprehensive plan, the city identified the GEOS site and its vicinity as a location for "suburban intensification" in the form of residential mixed-use development. The location is anticipated to be served by rapid bus service along a north-south arterial road that will connect to FasTracks – America's largest new commuter rail network being built out in the coming decade. The entitlement process for GEOS took two and a half years, included the writing of a sustainable mixed-use zoning code, required approval by a planning commission and city council, and involved extensive design coordination and collaboration with multiple government entities on the municipal and regional scale. Explaining their work as a "Demonstration Project," the project team found a receptive audience in many of the branches of government, and was therefore able to bend many regulations in order to incorporate sustainable systems.

The design process began with site analysis and extensive site reconnaissance. The existing greenway and historic patterns of drainage were found to provide the strongest qualities to the site. Places where these qualities were best experienced were turned into public pedestrian space. Linear parks following the flow of drainage became a driving vision -- connecting the new neighborhood and homes to large, social, urban squares overlooking the greenway. The

Figure 1: Land Use Plan showing residential and mixed-use building types arranged to optimize solar orientation with urban density.

project is designed as a neighborhood that will continue to connect to other future neighborhoods beyond its boundary to the North. A larger context of 75 acres involving adjacent landowners was studied as part of a larger schematic master plan before focusing down on the 25 acres owned by Norbert Klebl.

The proposed framework of open space was then woven into an urban fabric of streets, alleys, blocks, lots and building types. Sustainable systems and detailed design of landscape and architecture was then incorporated into this fabric. The density is at the higher end for new-urban scaled neighborhoods and was chosen for its walkability, its ability to achieve solar access, and how it complemented the lower-density surrounding suburbs. The total neighborhood will contain between 250 and 280 dwelling units on 25 acres – more than half of which is open space and rights of ways.

Net-Zero Energy

"Net-Zero Energy" means that energy produced is equal to and offsets the energy consumed. In Colorado, natural gas is the ordinary fuel for heating homes. At GEOS, there are no natural gas lines. Energy is conserved through a variety of passive measures, and harnessed from the sun and earth. The small amount of power consumed is electric and the neighborhood is tied to the electrical grid. GEOS will achieve net-zero energy because electricity production by rooftop photovoltaic panels, over the span of a year, will be equal or greater than the amount of electricity consumed in a year.

The first step with the Net-Zero Energy design for GEOS was to optimize urban density (a powerful energy saver in itself) with passive solar orientation. It is easy to design a passive solar home in the Denver exurbs on three acres. That

home would ordinarily incorporate the following: a good supply of windows on the south side with properly proportioned overhanging sunshades that block the summer sun; any windows to the west and east would be limited or shaded by deep porches and deciduous trees; on the north, windows and doors would be limited to what is sufficient for daylighting, comfort, and cross ventilation. A key accomplishment at GEOS was to design a dense neighborhood layout where all building types incorporate these solar orientation strategies. At GEOS, each dwelling has almost perfect passive solar orientation at a net density of 23 dwelling units per net acre.

Drawing from locally found Colorado types, as well as from European and South American precedents, a variety of building/lot/block configurations were evaluated by the design team for how they optimize urban density with passive solar orientation, and minimized doors and windows to the north, while still achieving a high quality of interior daylighting and comfort. The preferred patterns were then evaluated by the National Renewable Energy Laboratory who concluded that these arrangements would reduce heating and cooling loads by at least one third over other common configurations.

Figure 2: Section through the GEOS "Checkerboard Blocks." Buildings are spaced for winter passive solar gain

The solutions included several different building and lot types. Three story mixed-use and multi family buildings

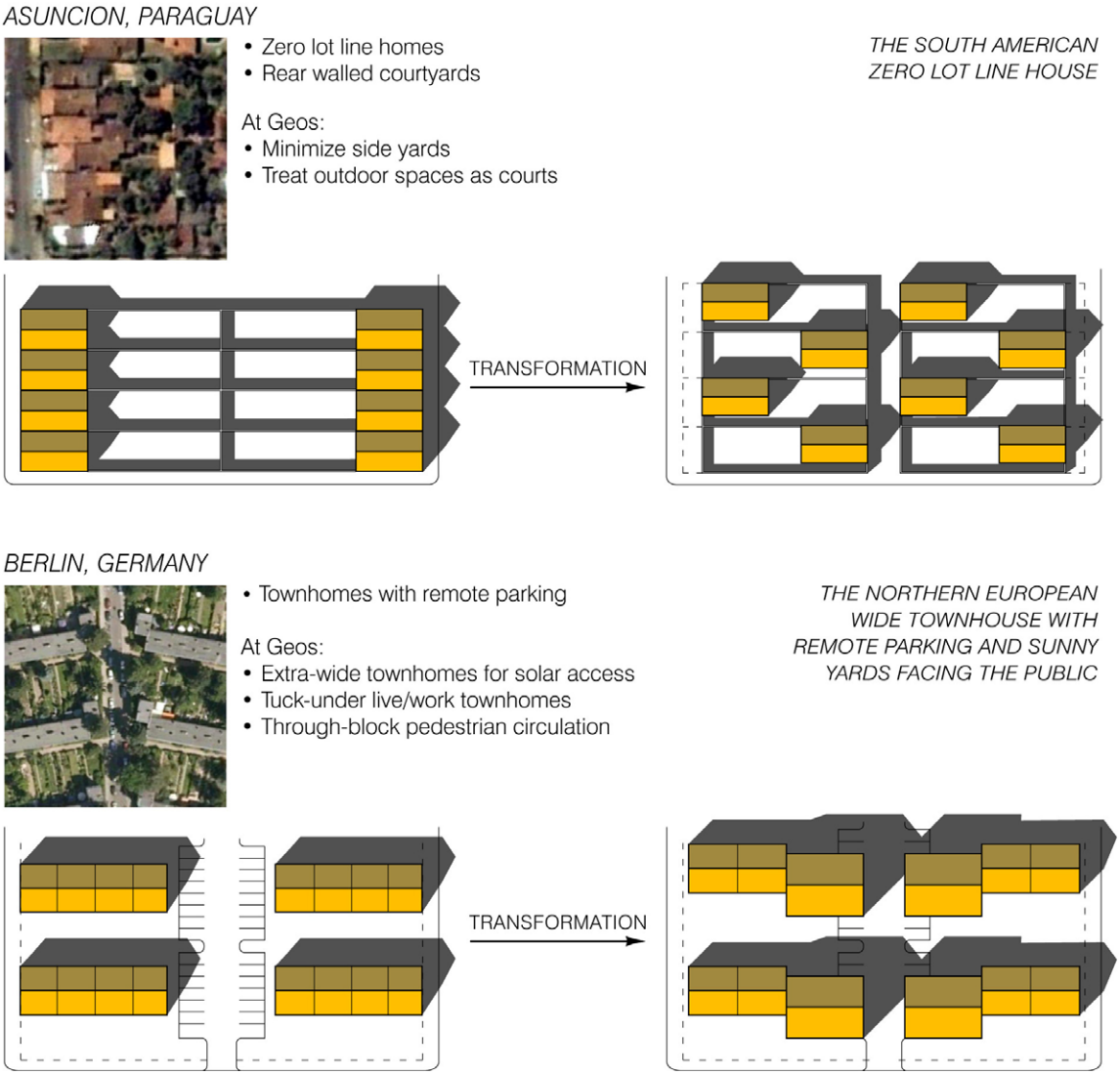

Figure 3: Latin American & European home types informed lot/block/building type innovations that optimize density with solar orientation.

Figure 4: Aerial of checkerboard block showing live/works at left which open to sunny south-facing yards, checkerboard homes at top right, and the central percolation park that filters stormwater runoff.

are stretched out in the east to west direction, with interiors opening to south-facing terraces and with minimal apertures to the north. Rows of townhouses are stretched-out east to west and spaced to permit winter sun to reach each row. At what are called the "checkerboard blocks," buildings are placed in a checkerboard pattern. Long, thin single family homes are stretched out east to west and placed in alternation at the front or alley ends of thin, 25' wide lots. This pattern is based on alley houses in the historic Highland Neighborhood of Denver. At the north and south ends of the blocks, homeowners park their cars off of north-south running alleys but the homes are stretched out east to west and open to sunny south-facing yards. Further, these live/work homes have 'squarish' floor plans that permit living and sleeping spaces to be arranged side by side along the south façade with services spaces to the north. The resulting checkerboard leaves missing gaps where in traditional neighborhoods one would find buildings lined-up at the same front setback. These gaps are sewn together via a four foot deep property line planting strip, and via habitable 'foyer' spaces shaped by trellises, benches, and small trees.

The passive solar homes are to be built to "passive house" standards. The building envelopes, built of super insulated structural insulated panels or SIPs, are ten times more air tight than typical new house construction. In such an air tight house, fresh air is needed. The heat recovery ventilator, or HRV, becomes the basis of the mechanical system. This system works year round providing exceptionally healthy, filtered, clean air. It also exchanges the heat of incoming fresh air with outgoing stale air – retaining 90% of the heat in winter. Incoming air is further tempered by being run through an underground pipe before reaching the HRV. Because of insulation, passive design, and the tempered fresh air, mechanical cooling for the house is not needed. For heating, a hot water coil is inserted into the HRV. This coil is heated via a ground source heat pump tied to an underground loop. The loop picks up the ground temperature via a liquid moving through the pipe. The heat pump works like a reverse refrigerator. It takes advantage of the abundant supply of liquid at earth temperature to pump heat out of that liquid and convert it to a higher temperature. This then provides space heating via the hot water coil, and heat for domestic hot water. In some parts of the neighborhood, solar thermal might be used as an alternative to the ground source heat pumps.

The GEOS neighborhood is not only designed to have net-zero energy buildings. It also aims to do so in a way that is cost neutral. To summarize the energy strategies: Passive solar design reduces energy demands by one third; the high performance, air tight building envelope reduces energy demands by another third. What remains is a home with one third the heating and cooling loads of a code-built house of equal size. But these homes are smaller than the typical American home. In 2004, the typical American home was 2,350 sf and most new construction was much larger. The first few blocks of GEOS homes will range in size from 1,100 to 2,000 sf and average less than 1,500 sf. This smaller size means that the average GEOS home will use less than 25% as much energy for heating and cooling as the average American home – and energy that is provided on-site from the earth and sun. These homes are expected to cost an additional $45,000 on average than the code-built home. But the monthly payment will be less. Additional costs for green construction get folded into a mortgage where the interest is tax deductable. This, combined with lower utility bills, leads to a net-zero energy home that costs no more to own than an ordinary home of the same size.

Figure 5: The GEOS homes will be built to 'passive house' standards with high performance, SIPs building envelopes, and Heat Recovery Ventilators in lieu of a furnace.

Civic Stormwater

Laced throughout the entire neighborhood plan is an approach to stormwater management that mimics natural systems. Rather than a concentrated detention and water quality system, stormwater is used throughout the neighborhood to help irrigate all landscapes while filtering pollutants. Further, this system is aligned with a diverse network of public parks and public circulation.

In private yards, roof runoff is routed through slightly depressed landscape areas called rain gardens. In rights of ways, between the sidewalk and the street is a system of street tree rain gardens. These collect runoff both from private yards, and from the street. The design is integrated with permeable walking surfaces that permit people to get out of their cars and walk to the sidewalk. Root balls of trees are lifted up above the level of the rain garden so that the trees do not suffocate in excess moisture, and an under drain wicks away water when the ground is saturated. The street tree rain gardens significantly slow down the time of concentration of stormwater runoff. This permits flood detention areas to be converted into usable public space.

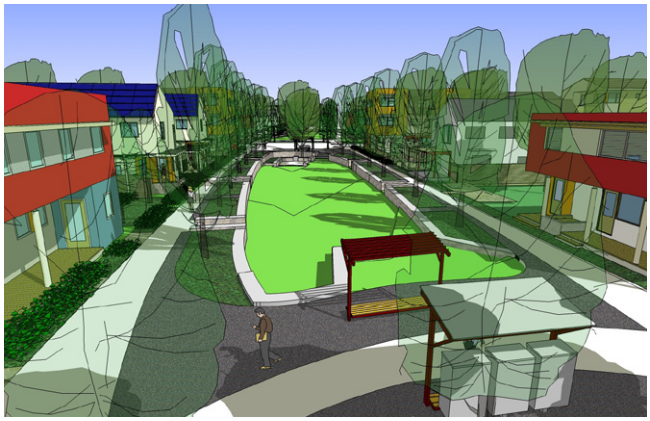

Figure 6: Each green is ringed by a terrace of fruit trees. A mail box shelter encourages socializing at the green's edge.

Running north-south through the neighborhood is a series of linear "percolation parks" or greens. These are several feet deep, surrounded by sitting walls, and are usable as child play areas, social places, civic spaces or as community gardens. The engineering function is detention during major

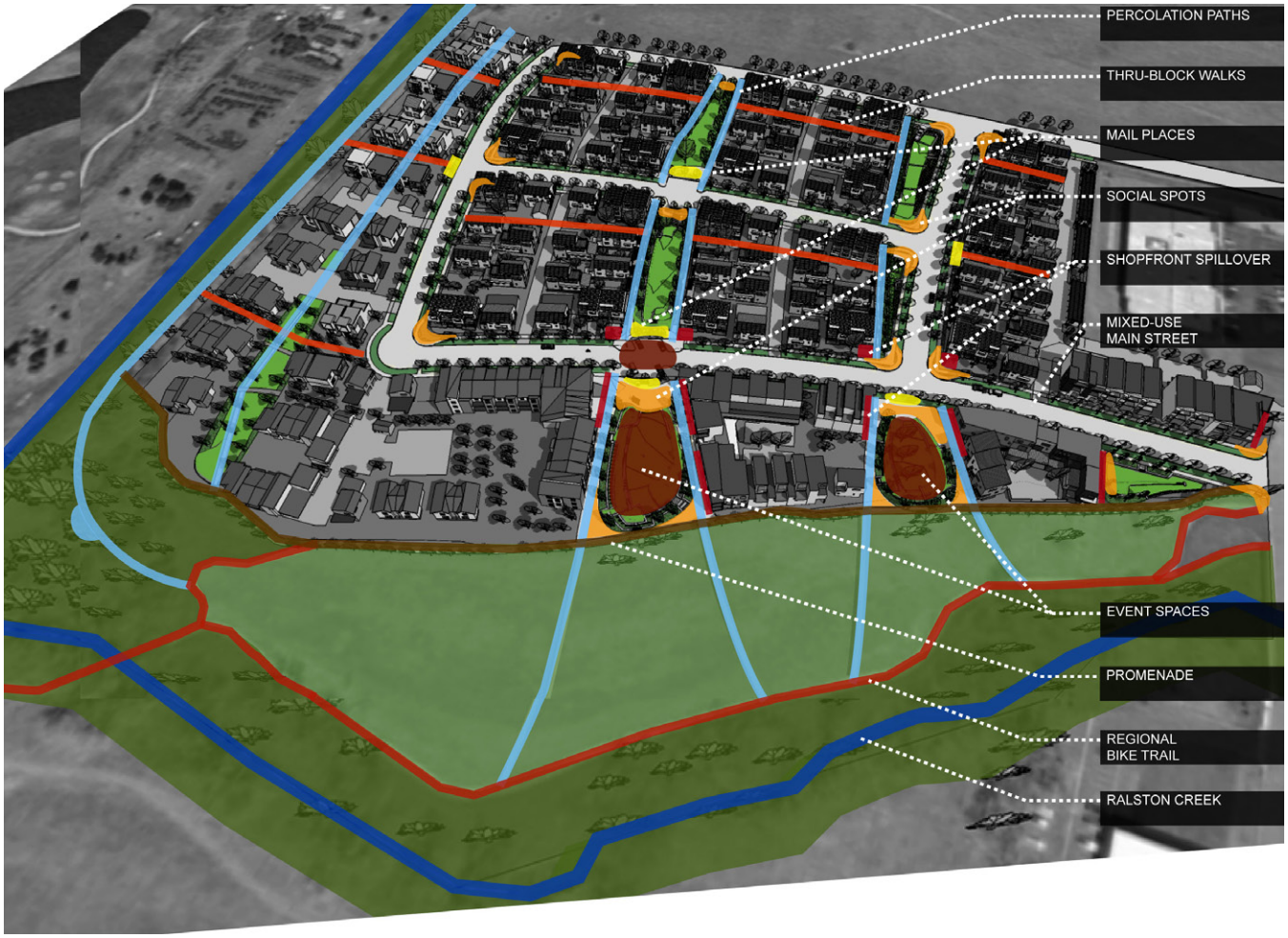

Figure 7: A diverse network of civic spaces is interwoven with urban drainage, places for agriculture, and access to winter sun.

flood events. But the series of rain gardens in the neighborhood is engineered to intercept most of the stormwater runoff so that the detention areas rarely receive significant runoff. Two of the parks function as town squares, with room to host public events. The flow of these percolation parks leads to the regional greenway which follows a creek upstream towards the mountains and downhill towards downtown Denver. The greenway also contains wild areas near the creek that are home to habitat, as well as supporting the 'wild' and unstructured play of children. The intent at GEOS is for pedestrian life and drainage to be brought together, bringing the value of water into civic consciousness.

Civic Life

The GEOS plan does not focus civic life in one central area. Instead, there is a complex and diverse network of paths, pocket neighborhoods, and corner stores that encourages extensive walking and the democratic development of a diversity of human relationships. In this way GEOS resembles a traditional urban neighborhood more than a village. As an improvement to traditional neighborhoods, GEOS will have a preponderance of small parks that receive winter sun and are designed to support community bonding at the micro scale, with opportunities for year round outdoor living close to the home, and play spaces that meet the needs of school age children better than traditional neighborhood parks. The town squares are located between the mixed-use main street and the regional greenway. They are surrounded by neighborhood-serving retail spaces, and cohousing with common houses, and can support public events like farmer's markets, weddings, concerts, and child's play. At the end of each green or square are mail box kiosks that support socialization when folks are picking up their mail.

Figure 8: Checkerboard live/work homes showing the street tree rain gardens that provide natural irrigation while filtering stormwater runoff.

Distributed throughout the neighborhood are opportunities for agriculture. Private yards are large enough for small garden plots. The percolation parks are ringed by a terrace of fruit trees. Each green is identified by a different fruit tree specie – forming a series of fruit tree coops across the neighborhood. The central area of each green contains space for small community gardens. And larger opportunities for agriculture are envisioned within one or two cohousing communities, and within the regional greenway.

A subtext of the neighborhood's design is to encourage a culture of stewardship. When peoples' life patterns are put in contact with natural processes at both the private and communal scale, it makes it easier for people to experience and interpret that relationship, and to move culturally into the habits of local stewardship and conservation. The mission of GEOS is not only to solve a problem of resource conservation technically. It is also to encourage cultural change – change in the culture of homeowners, and therefore change in the culture of homebuilding. The project team hopes that the design will form an armature that supports both individuals and the community to take the initiative.

Murray Silverstein, AIA
Partner, JSW/D Architects

Mr. Silverstein was a co-founder of the Center for Environmental Structure with Christopher Alexander and Sara Ishikawa, and between 1967-73, worked on numerous CES projects and buildings. He was Assistant Professor of Architecture at the University of Washington, Seattle, from 1968-70 and in 1974, he and Max Jacobson started the JS partnership in Berkeley, CA which would later become JSW/D Architects. Mr. Silverstein's publications include *Dorms at Berkeley: An Environmental Analysis*, with Sim Van der Ryn, *A Pattern Language*, and *The Oregon Experiment*, with his associates at the Center for Environmental Structure. With his partners at JSW/D, Mr. Silverstein co-authored *Patterns of Home* (The Taunton Press, 2001) and *The Good House* (The Taunton Press, 1992). In addition, he is the author of a book of poems, *Any Old Wolf* (Sixteen Rivers Press, 2006) and has edited an anthology of poems about the San Francisco Bay Area, *The Place That Inhabits Us, Poems of the San Francisco Bay Watershed* (Sixteen Rivers, 2010). He was a Visiting Lecturer at the School of Architecture and Urban Planning, University of California, Los Angeles, from 1974-80, and since 1981 has taught architecture courses at Antioch University, Diablo Valley College, University of California, Berkeley, and at the Harvard Graduate School of Design. Mr. Silverstein is a registered architect in California.

Michael Tavel, AIA
Principal, Michael Tavel Architects

Michael Tavel's recent work utilizes inventive building/lot/block layouts that permit the integration of solar and sustainable systems into compact, walkable urban neighborhoods. In 2006 he completed Solar Village, a mixed-use urban building in Longmont, Colorado. Breaking ground in 2010 is the 25-acre, 280-unit, urban mixed-use Geos Neighborhood in Arvada, Colorado, designed in collaboration with David Kahn. Geos optimizes urban density with solar access, integrates stormwater management throughout its town plan, and utilizes high performance building systems. It won a 2009 National Honor Award for Analysis and Planning from the American Society of Landscape Architects and is expected to be America's largest net-zero energy neighborhood.

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