An evolving mission

Constructing Sustainability

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## Transition to a circular economy

The building sector as driver

### Recalibrating the building process

Target Issues for Sustainable Construction

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### Almost off-grid: Ranch in California, USA

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An evolving mission

Constructing Sustainability
Transition to a circular economy: The building sector as driver

Edward Schwarz,
Holcim Foundation for Sustainable Construction
The creation of the Holcim Foundation for Sustainable Construction in 2003 occurred at an auspicious time. The need for change was in the air, and there was a deep belief that the building sector must become a driver of sustainability. A pioneering spirit prevailed, setting a worldwide agenda to reorient environment-making practices for decades to come. A landmark whitepaper was already on the table, the 1987 Brundtland Report that called for “meeting the needs of the present without compromising the ability of future generations to meet their own needs.” Up for discussion as well was the 1992 Rio Agenda that charted a comprehensive action plan to reduce human impact on the environment, along with the 1997 Kyoto Protocol mandating significant reductions of global greenhouse gas emissions. So much was clear regarding the broad recommendations for achieving sustainability.

Yet these general principles were somewhat abstract and not specific enough for a sector with a significant ecological footprint. The operational lifespan of buildings consume just under half of all globally available water, material, and energy supplies, while also generating nearly half of the total of carbon emissions and waste output. What was needed were more tangible guidelines that would bring building practices into line with international framework agreements but be more detailed in outlining specific commitments to sustainability within the construction sector, beyond just paying lip service to the cause. Sustainability for the Foundation, in other words, had to be literally constructed tenet by tenet, target by target, and technique by technique.

Amidst debates on which objectives for evaluating sustainable construction would be most effective, it was decided early on that the overwhelming lists of criteria from academic research and certification
councils would need to be distilled to form a set of concise targets applicable at all scales of the building sector. Common to all of them was the threefold imperative that whatever is built has to perform sustainably on environmental, economic, and social registers.

Accordingly, three issues were specifically identified that to this day have remained constant in the Foundation’s charter. Regarding the construction sector’s impact on the environment, what gets built must mitigate rather than contribute to carbon emissions. Regarding material and energy flows in the construction sector, what gets built must lead the transition from a linear to a circular economy of renewable resource use. Regarding the ramifications on people, what gets built must foster bonds and equity within society.

As timely as these core targets are, to build sustainably is not a one-size-fits-all directive, insofar as each world locality faces its own challenges and has recourse to its own ways of dealing with them. Place-specific solutions that allow for regional interpretation and adaptability to contextual particularities were therefore taken into account as a key criterion of sustainable development as well.

For the sake of forging new pathways, the Foundation also places a premium on innovation from the very beginning over and above material- and energy-intensive building practices, insisting that breakthroughs in construction – including rediscovered traditional methods adapted to new circumstances – are at the forefront of making our collective habitats more sustainable.
All in all, these interrelated concerns formed the basis of a new operational contract for the building sector, one that is as much environmental and economic as it is social and contextual in its scope.

Keeping in mind that the Foundation’s sponsor is a materials enterprise with global reach, it was not enough to simply make bold statements. For the ambitious objectives – or Target Issues as they would be called – had to be taken up in the everyday practical matters of the company to set an example of best practice throughout the industry. The bottom line was that corporate aims would have to be aligned with those of the Foundation and vice versa. Through the synergies and dialog established, the company would eventually adopt an integrated sustainability agenda that even challenged its own modes of operation. This agenda ultimately included progressive milestones for reducing carbon emissions, increasing waste recycling, and embracing measures to promote human rights in all facets of the construction sector. To this day, resource circularity, net-zero emissions, and compliance with the highest of ethical standards are at the core of the ongoing mission of both the Foundation and its sponsor.

What is still on the table and up for discussion in boardrooms as well as on construction sites around the globe is whether the disruptive transition from business-as-usual practices to planet-compatible ways of environment-making will proceed in small or large steps. That is, will change be radical or incremental? Whatever the answer, systemic over-haul or tweaking the status quo, the mission of sustainability becomes more urgent day by day as a pledge that must be put into action.
Recalibrating the building process: Target Issues for Sustainable Construction

Marc Angélil and Cary Siress
The Holcim Foundation for Sustainable Construction is committed to sustainability as an unconditional principle, asserting that environmentally conscious building practices require a mutually reinforcing interplay of responsible ecological, economic, and social objectives. In accordance with the Paris Climate Agreement\(^1\), the Foundation places a premium on the reduction of global greenhouse gas emissions in all construction-related activities to minimize further ecological deterioration. In keeping with the holistic cradle-to-cradle ethic, the Foundation also emphasizes the need for a circular economy of resource use at all scales, whereby what goes in and what goes out must be restorative and regenerative.

In alignment with the need to govern the places we inhabit as an equally accessible social commons, the Foundation promotes the democratization of all processes pertaining to the production and use of the built environment. Although there is growing awareness of the need for across-the-board decarbonization, circularity, and equity, construction processes must be further

\(^{1}\) Paris Agreement Under the United Nations Framework Convention on Climate Change, adopted in December 2015.
recalibrated in order to make the building sector a driver of innovation in sustainable development in all senses of the term.

To this end, the Foundation has identified five Target Issues as guidelines for sustaining the human-made habitat for current and future generations. These objectives provide an operational roadmap for all activities of the Foundation: evaluation of Holcim Awards submissions, expert round-tables, international conferences, research grants, next-generation laboratories, as well as best-practice publications. The five Target Issues for Sustainable Construction under the headings of Progress, People, Planet, Prosperity, and Place together are critical to making the environments we build and inhabit truly future-viable for all terrestrial stakeholders.

In light of the compound challenges facing the building sector, the Target Issues have been periodically adapted since the Foundation’s inception nearly two decades ago to reflect an evolving understanding of sustainability in construction. Accordingly, the Target Issues require ongoing review in the future.
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Progress
Innovation and transferability

Projects must demonstrate innovative approaches to sustainable development by pushing the envelope of practice and exploring new disciplinary frontiers. Breakthroughs and trend-setting discoveries must also be transferable to a range of other applications. Transferable innovations must comply with the principles of circularity and decarbonization, while demonstrating an awareness of the environmental impact of construction throughout a structure’s use-cycle. Possible innovations include:

- Triggering advancements in all practices involved in the production of the built environment including architecture, urban design, landscape design, territorial planning; in civil, urban, and environmental engineering; in materials science; and in manual and digital manufacturing;
- Introducing groundbreaking approaches to design, construction techniques, and material production, or experimental solutions for load-bearing structures, enclosures, mechanical systems, as well as building processes, operations, and maintenance;
- Making original contributions to the improvement of social relations and livelihoods via pioneering user-oriented design propositions and novel use scenarios;
- Establishing new monitoring methods for evaluating the project’s objectives and its performance over time;
- Applying novel means of disseminating research findings and practical know-how, including project documentation, communications and public outreach, as well as education and training programs.
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Knitted formwork

Best Practice example in Mexico City, Mexico
The project for a pavilion comprised of three parabolic arches was built using a cable-net and fabric ultra-lightweight formwork system with integrated inflatable chambers onto which a thin layer of concrete is sprayed to create the outer shell. The thin, double-curved concrete shell with a surface area of 50 square meters and weighing 5 tons was applied onto a knitted formwork weighing only 55 kilograms. The combination of digital and manual techniques is ingenious in that it significantly reduces the material required to create the formwork as well as the amount of concrete used for the shell, while enhancing the aesthetic quality of the Félix Candela-inspired structure. The design triggers progress in many practices involved in the production of a more sustainable built environment.

“KnitCandela” at Museo Universitario Arte Contemporaneo (MUAC), Mexico City, 2018. Zaha Hadid Architects (Computation & Design Group), London, United Kingdom and Block Research Group (Philippe Block, Tom Van Mele & Mariana Popescu), ETH Zurich, Switzerland. Philippe Block has been a member of the Academic Committee of the Holcim Foundation since 2014. The Holcim Mexico Center of Technological Innovation for Construction (CiTeC) developed a concrete mix to realize the expressive shell structure.
Best Practice example in London, United Kingdom

In response to London’s housing shortage and to provide affordable accommodation where people work, this project offers a resourceful solution for constructing living units above parking spaces all over the city, where expensive land costs are replaced by more affordable leased air rights. This approach to sustainable design pioneers a user-oriented solution to urban housing affordability. The straightforward proposal could contribute to a more environmentally sound approach to land use at a larger scale. Emissions are reduced during the manufacturing process as well as throughout building operations due to the choice of materials and energy sources, in effect, demonstrating how a cost-effective, low-carbon architecture can have high impact with minimal means.

Low-carbon protein

Best Practice example in New York City, USA

In an effort to mitigate the environmental footprint of meat-based diets, the project demonstrates the advantages of local insect farming as a low-carbon and clean-energy source of a protein-rich staple. This urban farming alternative to animal meat production emits 1% of the greenhouse gases and requires 0.001% of the land required to produce the same amount of protein via beef production. By using a minimum of land and reducing greenhouse gas emissions in the process, the cricket mating station innovatively responds to the UN mandate for promoting insect-sourced protein as a means for offsetting the negative impact of food production as well as pending global food shortages.

Projects must adhere to the highest ethical standards and promote social inclusion at all stages of the process, from planning and construction to use, servicing, renovation, and decommissioning. To ensure an enduring positive impact on communities, proposals must demonstrate how to enhance the collective realm and how affordable and socially inclusive habitats can be sustained, including the fair distribution and management of resources. Possible contributions include:

- adhering to ethical standards in all phases of a project’s use-cycle;
- fostering the formation of socially viable environments, strengthening of shared values, and enabling community empowerment;
- ensuring equal participation of stakeholders, including users, clients, neighborhood affiliations, co-operative members, state and local authorities, as well as non-governmental organizations;
- improving the quality of working conditions in the construction sector, whether pertaining to the provision of on-site amenities, fair compensation, adequate benefits, proper sanitation, and safety measures or guaranteeing gender parity and ethnic equality;
- increasing political transparency, promoting unbiased tender processes, demonstrating a commitment to principled interaction among involved parties, upholding codes of conduct for contractors and suppliers, and endorsing just business practices, all in the effort to prevent corruption at any level of planning and construction processes.
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Best Practice example in El Marj, Lebanon

Pavilions from the 2015 Milan World Expo are repurposed as school buildings for Syrian refugees in Lebanon. Circularity is put to work for a humanitarian cause through the imaginative re-appropriation of structures otherwise slated for demolition. Disassembled for transport, the structures are reassembled with active engagement of residents and outfitted with local materials such as sheep wool for thermal insulation and recycled wood for furnishings. In a context lacking basic infrastructure, the school offers a dignified environment that is a source of pride, while also promoting social inclusion and providing a place to rebuild the social fabric of the community.

Training through construction

Best Practice example in Ambepussa, Sri Lanka
The project uses the construction of a community library to reskill former soldiers and integrate them into Sri Lanka’s workforce, building vocational capacities and fostering the recovery of human capital in an effort to deliver an enduring positive impact on communities. There is a strong connection between low skill levels of workers and poor-quality structures. The solution is to design a structure so that training can be part of the construction process, and the design itself has plenty of margin for error that accommodates the skills and equipment of the labor force. Lessons learnt from this prototype can be readily transferred throughout the building industry and inform hands-on policies for boosting labor capacity.

Best Practice example in Dandaji, Niger

The renovation of a derelict mosque and its repurposing as a new literacy center promotes the education of women in order to strengthen their role within society. The construction of a new mosque nearby provides local artisans with an opportunity to reinterpret traditional building techniques through the incorporation of new materials and knowledge – creating a juxtaposition of old and new, and raising awareness of environmentally compatible methods. The legacy of embedded knowledge is applied to new circumstances that demonstrate how low-tech solutions are equally responsive to enhancing sustainability. Also by providing women in the community with additional spaces for literacy, accounting courses, and workshops, the design leverages knowledge as a means to social inclusion and economic advancement.

Projects must exhibit a sensible deployment and management of resources throughout their entire use-cycle. Long-term environmental concerns, especially in view of optimizing circular flows of material, water, and energy, should be an integral part of the design and construction approach to minimize greenhouse gas emissions, reduce waste, and promote the use of regenerative resources throughout the industry. Possible approaches include:

- minimizing a project’s ecological footprint and maximizing its positive impact on the environment through more lean input-output cycles;
- devising environmentally conscious land use strategies and policies that preserve the existing landscape and at the same take water and wildlife preservation as well as land reclamation into account;
- emphasizing the use of renewable energy in construction as well as in the use and upkeep of the built fabric to lower carbon emissions;
- deploying renewable material resources, while mining existing building stocks, minimizing the consumption of water, and reducing waste;
- using resilient, durable, and environmentally sound technologies, developing robust construction details, and ensuring the optimal interaction of building systems.
Net-zero living lab

**Best Practice example in Singapore**

Challenging the notion that an energy-efficient building has to be closed and airtight, the project shows that sustainability requires a deep understanding of the local climate. A large overhanging roof and double façades shade the building from the sun’s heat and provide a cooler interior. The building design uses of the architectural concept of “floating boxes”, where its shallow plan depth and porous layout allows for cross-breezes, natural lighting and views to the outdoors. Long-term environmental concerns to optimize circular flows of material, water, and energy are an integral part of the design and construction approach.

This university facility combines high- and low-tech solutions to achieve net-zero energy consumption for its operations. Photovoltaic panels power the hybrid cooling system using natural ventilation and also generate an energy surplus.

**School of Design & Environment**, National University of Singapore (NUS), Singapore, 2013-19. Serie Architects + Multiply Architect, Surbana Jurong (Christopher Lee, et al.), Singapore; Transsolar KlimaEngineering (Matthias Schuler, et al.), Stuttgart, Germany. Matthias Schuler was a member of the Global Holcim Awards jury 2015 and the Holcim Awards jury Europe 2017. Christopher Lee was a member of the Holcim Awards jury Asia Pacific 2020. National University of Singapore is an associated university of the Holcim Foundation since 2018, represented by Nirmal Kishnani, Professor of Architecture; he was a member of the Holcim Awards jury Asia Pacific 2017 and Head of the jury Asia Pacific 2020.
School of air and clay

**Best Practice example in Gando, Burkina Faso**

The use of indigenous materials and construction techniques for a school in an arid region of West Africa proves that an economy of means can yield a highly sustainable structure as environmentally conscious as it is aesthetically accomplished. Built by residents drawing on local know-how, the school project keeps traditions alive and is just as innovative as a green, community-building initiative. The project’s ecological footprint is minimized using a blend of locally sourced earth, sand, and gravel stabilized with cement that is cast in-situ to create self-supporting curved walls. The roof channels air throughout classrooms that are passively cooled via a geothermal register, while thick walls further moderate the internal climate.

Every drop counts

**Best Practice example in Mexico City, Mexico**

Serving a low-income neighborhood of Mexico City, the project combines much-needed water infrastructure with the public amenity of a park in a context lacking both. Working with the existing topography, stepped plateaus and a series of civic structures form a rich ensemble of interlocking courtyards and platforms overlooking catchment basins that mitigate flooding during heavy rainfall. The design devises an environmentally conscious land use strategy that foregrounds the preservation and value of water. This constructed, socio-technical landscape, addressing the needs of both the environment and the community, raises awareness of the importance of water management as a collective responsibility.

Projects must be economically feasible and able to secure financing, whether from public, commercial, co-operative or concessional sources, while having a positive impact on the social and physical environment. An economy of means in construction must be pursued in order to avoid the wasteful consumption of materials and limit carbon emissions. The products used as well as construction processes deployed must adhere to the logic of circular economies. Possible strategies include: relying on legitimate and transparent funding sources, while guaranteeing that any revenues generated are lawfully declared and benefit stakeholder communities as well as wider publics; conceiving the project in view of its links to broader economic frameworks of local, regional, national, and global monetary flows; seeking robust economic models that take unpriced external costs into consideration from the outset; demonstrating a project’s flexibility to adapt to future changes of user needs, ownership, laws, and regulations, as well as adaptability to economic fluctuations; introducing long-term economic incentives for reducing waste and harmful emissions throughout a project’s entire use-cycle.

Prosperity
Economic viability and compatibility
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Recycling through leasing

Best Practice example in Dübendorf, Switzerland

Putting use-cycle thinking at the forefront of design, the research project on the campus of the Swiss Federal Laboratories for Materials Science & Technology (Empa) shows how a more responsible approach to mining the city for resources can go hand-in-hand with appealing architectural form. An economy of means in construction must be pursued in order to avoid wasteful consumption. A circular economy is promoted through the notion of product leasing, whereby buildings – comprised of fully recyclable components – are understood to be temporary aggregations of materials that can later be recirculated for future use. Materials will be routed back to their biological and technical cycles after deconstruction (planned for 2023).

Urban Mining & Recycling Experimental Unit, Swiss Federal Laboratories for Materials Science & Technology (Empa), Dübendorf, Switzerland, 2017-18. Institute for Lightweight Structures & Conceptual Design, University of Stuttgart (Werner Sobek) and Karlsruher Institut für Technologie (Dirk Hebel & Felix Heisel), Germany. Werner Sobek was a keynote speaker at the Holcim Forum “Re-inventing Construction” in 2010 and member of the Global Holcim Awards jury 2018. Dirk Hebel has been a member of the Academic Committee of the Holcim Foundation since 2017.
Lived appropriation

**Best Practice example in Iquique, Chile**

The half-house concept responds to the immediate need for affordable dwellings that are also adaptable to future needs. The approach to public housing ensures construction meets budget and time constraints that may be imposed by government administrations, but still provides the opportunity for expansion via self-built construction in the future. This design flexibility thereby ensures revenues available have the maximum positive impact on the physical and social environment. By reducing the cost for constructing each housing unit at the outset (since only the first half of the house is built initially), the project budget can deliver more units for more people – thereby initiating a sustainable method for addressing housing shortages worldwide.

**Affordable Housing**, Iquique, Chile, 2002-present. Elemental (Alejandro Aravena), Santiago, Chile. Alejandro Aravena has been a member of the Board of the Holcim Foundation since 2013. He was a keynote speaker at the Holcim Forum “Economy of Sustainable Construction” in 2013, member of the Global Holcim Awards jury 2015 and 2018 (as head). “Elemental: Housing as an Investment not a Social Expense”, Andrés Iacobelli & Alejandro Aravena in *Urban Transformation*, Berlin: Ruby Press, 2008.
Spatial dividends

Best Practice example in Bordeaux, France

With the transformation of a rundown housing block from the mid-20th century, the project offers proof that renovating the existing building stock is cheaper than demolishing and building anew. Not only is an economy of means pursued through the use of ordinary materials, but relocation costs are eliminated as well, insofar as residents can remain in their homes during construction. All units are enlarged through the addition of a generous winter garden and balcony that, while reducing energy use, offer more space for users without increasing monthly rents.


Place
Contextual and aesthetic impact
Projects must convey a high standard of architectural quality in responding to the social and environmental urgencies of the present and those to come. With space, form, and aesthetic impact of utmost significance, the material manifestation of the design must make a positive and lasting contribution to the local context as a prevalent form of cultural expression. Possible measures include:

- improving existing contextual socio-spatial conditions;
- fostering interdependencies of landscape, infrastructure, urban fabric, and architecture;
- working with the given building stock through sensitive restoration, reuse, or remodeling of the built environment;
- inventing programmatic strategies in terms of new uses, multiplicity of functions, short-term flexibility, and long-term adaptability;
- cultivating architectural excellence and aesthetic impact, specifically with regard to spatial ambiance, sequences of movement, inside-outside relationships, material tactility, light variation, and related place-making qualities.
Networked micro-catalysts

Best Practice examples in Indonesia
The proposal for a nationwide network of microlibraries aims to promote literacy in Indonesian communities lacking basic educational infrastructure. Working at the territorial scale of the country and local scale of individual towns, the facilities intend to empower the population through grassroots modes of knowledge dissemination, while being responsive to the specificities of place. The series of microlibraries make a positive and lasting contribution to the local context. In lieu of the closed and air-tight environment of a conventional library, these modestly constructed interventions are open to their surroundings in both the flow of air and of people, always being paired with other communal activities to encourage civic engagement in local affairs.

Microlibrary in Indonesia - Network of decentralized libraries as community learning centers, Indonesia, 2012-present.

SHAU (Daliana Suryawinata & Florian Heinzelmann), Bandung, Indonesia. Winner Holcim Awards Silver Asia Pacific 2017.
Best Practice example in Culver City, CA, USA

The expansion and reuse of a former wallpaper factory as art studios for a university demonstrates how to straightforwardly mine the building stock of the city for its own benefit. The design works with the given building stock which has been the site of the art studios since the mid-1980s. Through sensitive restoration and remodeling of the built environment, the refurbished and expanded facility retains its provisional character as well as its capacity for long-term adaptability for transformation in the future. The art studios take an innovative passive approach to climate control, and demonstrate a sensitivity to the interdependencies of urban fabric and infrastructure – that hold lessons for other architects.

Elemental Construction in California – Warner Graduate Art Studio renovation and addition for the University of California Los Angeles (UCLA), Culver City, USA. Johnston Marklee (Sharon Johnston & Mark Lee), Los Angeles, USA. Winner Holcim Acknowledgement Prize North America 2017. Mark Lee was a member of the Holcim Awards jury Asia Pacific 2008. Sharon Johnston was a member of the Holcim Awards jury North America 2020.
Public space reservoir

Best Practice example in Medellín, Colombia

The decommissioning of a water management facility offers the opportunity to reconsider how inaccessible parts of the city can be reclaimed as public spaces accessible to all. Instead of demolishing the water tanks, the once hidden grounds are converted into a park and community venue for cultural and sporting activities, thereby creating a collective place where none had existed before. By focusing on the context of the site, the design creates a contextual improvement to socio-spatial conditions. Situated at the nexus of architecture, landscape, and infrastructure design, the project gives a second life to a defunct urban site by reintegrating it within the civic realm of the city.
Almost off-grid: Ranch in California

Sarah Graham
Best Practice example in Santa Ynez, CA, USA

It all began with a few rounded stones casually placed on an ordinary newspaper. The stones represented what were to become the main spaces of a new ranch house overlooking the surrounding countryside of Santa Ynez. The newspaper, showing a map of the California coast, was cut and folded to correspond to the size of the site. From this impromptu model, the first idea that came to mind was of oval-shaped structures that would allow a 360-degree view of nearby mountain ranges and valleys. Hence the stones.

As fun as this rock-paper-scissors game may have been, it soon became clear that this was the wrong approach altogether. For one thing, ovals are notoriously expensive to build. For another, this seemed too literal an interpretation of the loose arrangement of stones on paper. Better to draw on the raw properties of the land and the qualities of the place as the basis for design than to begin with a predetermined form. More attention would be paid to the folded newspaper, meaning the site itself. The site would be utilized as the prime resource for designing the house and the entire ranch, and the operation began with the ranch.
Re-sourcing a site

Resource and environmental performance
How do you get a site somewhere out there in rural Santa Barbara County to work in the most ecologically minded way possible? To begin with, you become aware of what is at hand and how it is already working. Water, for starters, is no small issue, especially in a state prone to extended periods of drought, so how to best collect, store, and use it efficiently were of primary concerns when considering the general layout of the facilities.

While it supposedly never rains in Southern California, or all too seldomly, all rainwater was to be collected either on the ground or on roofs, used for irrigation, and then channeled through the existing topography to replenish the natural aquifer. To access this vital subterranean reservoir, a well was strategically located with a pump strong enough to draw water from 150 meters below ground – the well being an amenity, by the way, considered important enough here to warrant its own street address. Equally important given the ever-present risk of wildfires, a sufficiently sized water tank had to be placed on the highest topography to assist those much-revered community firefighters in case of an emergency.

After the issue of water supply had been addressed, its off-grid dispersal and the means for treating both black and grey wastewater were designed, prompting the installa-
tion of multi-chamber septic tanks and drain fields that function as on-site sewage systems. Once treated, the residual liquid percolates through the ground sediment and seeps back into the aquifer to complete the on-site water cycle.

In all, water was central to the overall design of the ranch, determining not only the placement of the various structures, but fundamentally how they work together to optimize the use and reuse of an increasingly scarce resource.

Another determining factor in the overall design was the use of renewable energy to minimize the ranch's carbon footprint. Given the ample amount of sunlight in the region, a 23kW-array of photovoltaic panels was installed on the roof of an existing barn to provide all of the power required
for the entire property, including the well pump, agricultural buildings, and living units. Although the goal was to make the ranch self-sufficient with regard to energy production and consumption, off-grid, as it were, it proved to be more efficient to plug into the public utility network and, as is common practice, use this networked energy reservoir to store any electricity produced on site for current and future needs. Any surplus generated is credited to the owner, excluding administrative costs.

The ranch’s annual production to date has been approximately 36,400 kWh and use 30,900kWh – with the largest draw being the well - thus returning a surplus of 15% to the grid, a reserve for future use if necessary. Not only does this system eliminate the need for costly batteries and accordingly the toxic hazards that come with their disposal, it also amplifies the circular economies at work in the operation of the ranch.

Concerns for water management and energy production led to discussions about what the site could yield in terms of crops for both the
human and animal inhabitants of the compound. As a matter of principle, everything planted was to be edible. Besides being a horse boarding facility outfitted with the requisite stables, pastures, and training grounds, the site would also serve as an agricultural farm, cultivated to produce fruit, vegetables, nuts, olives, eggs, and herbs for humans as well as grass and hay as animal fodder. Any surplus food that is not consumed by the residents and friends is donated to the local nonprofit organization Veggie Rescue that provides pick-up and delivery services catering to needy communities in the area, keeping in mind that more than 20 percent of the region’s population is threatened by food insecurity.

That said and with every effort made to get as much from a harvest as possible, a farm nevertheless produces plenty of organic waste, tons of horse manure included, all of which needs to be collected, aerated, moistened, and covered before being distributed back onto the fields and gardens as composted fertilizer. Here again, whatever is produced

Cistern for collecting runoff rainwater.  Composting facility.
is reused on the property within a larger circuit in which the ranch serves the farm and vice versa.

Such measures essentially reframed landscape architecture as it is usually practiced. The site design was based on infrastructure and systems installations rather than one focusing on formal composition – no groomed lawns or manicured hedges, but rather the channeling of material and energy flows already at hand. The site itself, in other words, was “re-sourced” in view of its intrinsic operative capacities to generate, amass, and recycle in perpetual and productive loops.

This logic of landscape and resource management was established throughout the property before the house was designed, setting up the rules of the game for the architecture in a clear, appropriate, and exciting direction.

Following the principle that everything grown must be edible, crops are grown year-round in designated agricultural fields that provide a steady supply of food, with any surplus distributed to communities in need.
Economic viability and compatibility

If the initial planning phase took into account circular economies of the site as the basis for decision-making, an economy of means would determine the construction of all habitable structures on the grounds. But prior to building the ranch house, an experiment was made to test just how cheap the process of building could really be. To this end, an existing horse barn was transformed into a live-work space for humans using available on-site materials as well as the most inexpensive industrial and agricultural supplies sourced as locally as possible, with “99¢ being the modus operandi of the overall design investigation,” to quote the architects. A wordplay on the name of the American 99¢ Store franchise, this exploration of “How low can you go?” – to use another American idiom – reflected the core ambition and the overall spirit of the project.

But say 99¢ to anyone in the trade, and the first question is most likely, “99¢ per what unit?” The point here, however, was less about metrics or numbers on a spreadsheet and more about calling attention to the often-opaque pricing of building products in general. Far from mere rhetoric, the 99¢ price tag raised the broader question as to what extent one really knows how much building elements should cost in the context of today’s highly competitive global market.

We used to know how much a toilet should cost. A reliable one was US $500. Pay more and they get too complicated; pay less and they break. Now, however, we don’t know anymore. With the Internet, overstock supply

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Andy Warhol, Dance Diagram (Tango), ca. 1962 (Image: Andy Warhol Foundation for the Visual Arts).
sales, and global distribution, we don’t know how much we should pay for toilets or faucets or lights or anything else that goes into a building. And how much should we pay for shelter? Why can’t we build lightly rather than with heavy, redundant layers? Building codes provide an immediate answer as to what is not allowable, but what is possible? Why can’t we use the straightforward, economical systems of agriculture and industry for building shelter?

The experiment with the barn conversion was meant to address these very questions, calling for concerted deviations from business as usual. The first move, before anything new was ordered, was to take stock of all materials on the ranch that could be repurposed, either to convert the existing barn, to upgrade another barn already standing, or to construct additional
animal shelters, given that what was already at hand provided a wealth of embodied energy. This stocktaking subsequently set off a veritable flow of materials across the site, be it wall elements, mesh panels, stall doors, assorted structural components, and so forth, as if tracing out coordinated lines of movement not unlike those depicted in Andy Warhol’s *Dance Diagram* from the early 1960s, as referenced in the 99¢ Space exhibition by agps architecture originally shown at the Architektur Galerie in Berlin.

The material shuffle at Refugio Road Ranch, involving the recirculation of bits and pieces of buildings, would yield a bare-bones framework that could be filled in and modified according to specific requirements.

In keeping with the design tenet of cheap, no-frills materiality, the next task was to identify external sources for low-cost building components beyond those available on site. The market is awash in assorted product brochures, mail-order catalogs, and e-commerce websites, each featuring the latest in construction supplies for small industrial and agricultural facilities.

The search for the most affordable, most environmentally sound, and most ethically accountable product lines would generate, in due course, a substantial library that included the likes of FarmTek, MD Barnmaster, McMaster-Carr, Viagrow, 1000Bulbs, ULINE, etc., all sitting on the shelf
next to standard editions on art, architecture, and literature. Having reviewed the various catalogs, the architects compiled an itemized list of components ranging from the very large to the most minute. Larger elements from prefabricated barn and greenhouse kits, for example, were employed as enclosure and structural framing. At the other end of the scale, items like off-the-shelf tension cables, turnbuckles, standard-gauge piping and conduits, as well as construction-grade plywood and corrugated cardboard were used for outfitting the interior.
The construction of the “99¢ Space,” as the barn conversion was eventually named, required another ethos altogether than that typically practiced by the same architects who labor over the resolution of precise details and finishes.

On the contrary, everything assembled here was rough, raw, and ready to use. The ‘lite’ structural framing was pounded into place and bolted together without fuss, resulting in a pared-down pragmatism that gives...
the space its Spartan quality. As with the load-bearing structure, the facade is a blend of new and existing components put together in simple layers. Former stall doors were clad with recycled corrugated fiberglass sheets and then reinstalled as moveable panels on the exterior. Translucent sliding doors were mounted on the interior, allowing the space to be completely opened to the outside. A silver mylar curtain – the only
high-tech material brought in, developed by NASA but cheaply sourced through agricultural greenhouse suppliers – was hung on the inside with tension cables, duct tape, and magnets as attachment hardware. In addition to providing privacy and regulating light, the curtain insulates the space. All in all, the investigation of cheap construction was carried through to every aspect of the work, determining design decisions large and small.
By sheer coincidence, silver mylar foil would unknowingly take on a new significance far beyond the ranch, becoming in a broader political sense a symbol of resistance amidst the controversy over US immigration policies. Just after construction had begun at Refugio Road Ranch, wide media coverage showed migrant detention camps with children separated from their parents wrapped in mylar blankets. It would not be long before mass protests broke out with demonstrators from coast to coast wearing silver foil as a sign of defiance. This is no small issue in a state like California, where a large portion of its population is made up of immigrants from south of the border, both legal and illegal. And this was no small issue on the ranch itself, since the Mexican families who live and work there expressed their immediate concern about the unfolding political events at the time, cheap materiality notwithstanding.
Fluxes of common use

Ethical standards and social inclusion
While inexpensive in its construction and maintenance, the 99¢ Space is rich in its variability of use. The open space allows for a high degree of adaptability for all types of indoor and outdoor functions. At one end, there is always someone going in or out of the toolshed for a shovel, rake, or axe, or someone repairing something, while someone else on a tractor is busy loading or unloading bales of hay. At the other end of the building, the multifunctional room buzzes with residents going about their daily business, be it drying herbs and peppers, cleaning vegetables and fruit, making a variety of preserves, building cabinetry, sharing lunch, or children doing their homework. Later, the 99¢ Space was named “the schoolhouse” by kids forced to stay home during the COVID-19 pandemic, as this was where they studied.

Within the space, all of the furniture is on wheels and can accordingly be arranged at will. The space can also accommodate periodic guests, with tables designed to be converted into beds and mobile storage units rolled out to become nightstands. There is also a small kitchen and bathroom that are closed off with sliding stall wall panels. The flux of everyday activ-
ities brings this modest building to life as the hub of a ranch that is home to 12 people, 18 horses, 20 chickens, 3 dogs, and 2 cats, not to mention the assorted wildlife that regularly wanders onto the premises – a mix ensuring that there is always something going on and, of course, always something to fix.

Just as the 99¢ Space is open to commonplace uses it is also appropriated by residents for special events. There are frequent barbecues, occasional horse clinics, or the annual Cinco de Mayo festivities. The space is used for the yearly Christmas party held in honor of the workers and their families. When rearranged for celebrating the First Communion of one of the children living on the ranch, the space was redressed with colorful paper lampions, garlands, and a piñata hung from the trusses. The wedding for one of the resident family’s relatives was even more elaborate, with a very loud mariachi band playing just inside the main space to a sizeable audience drinking, eating, and dancing outside. And who knows what else is in store for the 99¢ Space – not only a lively hub, it has since evolved into a kind of commons for life on the ranch and the community beyond.
An object lesson

Innovation and transferability
The barn conversion proved to be instructive as an experiment in doing more with less, inasmuch as those earlier concerns about resourcing the site, cheap materiality, and fluxes of use informed the concept, spaces, and detailing in the design and construction of the new house. What had begun as a few stones laid on a newspaper became a collection of indoor and outdoor spaces assembled under one large roof - three terraces, two living units, and one workspace. They all fit together like pieces of a jigsaw puzzle through which the occupants move in and out while going about their everyday activities. A freestanding object in the field, the ranch house has varying degrees of transparency and opacity. In places, it is fully open to frame views of the landscape beyond; in others, the house stands out sharply from the surroundings as a constructed silhouette, thereby enmeshing the artificial and the natural.

What is key to the project’s circular economy is that the house is plugged into the off-grid systems of the ranch, the most important parts of which are the water well, the photovoltaic array, and the on-site septic sewage system, together forming the necessary base infrastructure for water, power, and human waste management. With this hands-on interlinking of systems, the site itself functions as the key resource and main facilitator of the house’s operations.
Additionally, the well at the eastern end of the property provides not only potable water, but also the water needed to cool or heat the spaces of the house. Once the water is drawn from the aquifer (in this case considered as an energy reservoir), it is routed to a heat pump and a buffer tank, both regulating the difference between the temperature of water in the ground and that used for the in-floor heating and cooling system. Considering that the temperature of the groundwater in the region is moderate (62°F/17°C), relatively little energy is needed to either cool or heat the building. In short, aquifer, water well, heat pump, buffer tank, and in-floor coils are all connected to condition the interior environment of the house. An app on a mobile device is used to control the temperature throughout, putting the occupants inside the machinery, as it were, wherever they may be.

Covered in corrugated galvanized metal, a common agricultural product, the roof is as much an integral piece of site infrastructure as it is a
functional component of the house itself. The long, south-sloping plane, conceived as a large umbrella lifted slightly above the roof construction, protects the indoor and outdoor spaces from direct sunlight. It is sloped to channel rainwater to a cistern at one end that is used for irrigating the garden. Given its size, the roof could also accommodate an array of solar panels should an extension to the existing installation ever be necessary.

In order to reduce the new house’s environmental footprint and considering that everything needed for construction had to be brought to the site, material flows were kept to a minimum.

No grading was made to the land itself, as the house sits on a concrete platform hovering just above the existing topography. Likewise, no earth was moved off-site for the construction of the foundations, their number and dimension reduced to what was structurally feasible. The concrete foundations, slab, and grade beams are carbon-reduced, utilizing locally
sourced aggregate, reduced water demand, and replacement of recycled fly ash for 25% of the Portland cement, with an estimated CO2 reduction of 20%. The concrete floor is exposed throughout, giving expression to the doing-more-with-less approach and the logic of reduced layers and materials.

In terms of the load-bearing structure, only a few slender columns support the house. The steel moment-frame was produced locally with just over 90% recycled content, its dimensions purposely minimized as well. Standard wood framing for walls and floors complements the concrete and steel, all coalescing to form a hybrid construction that draws on the interplay of distinct material qualities working in unison. Often hidden but here exposed, these combined efforts to lessen the house’s environmental impact, starting from the ground up, resulted from a lively back-and-forth exchange (another dance of sorts) among the architects,
engineers, and contractors. The house was constructed with standard farm-tech products, some sourced straight from those agricultural and industrial catalogs used for the barn conversion yet tweaked here and there to enhance the building’s environmental performance. A case in point is the double layering of the façade, a principle infrequently employed in the United States, though common in Europe.

The inner wall, a basic steel frame with wood infill, is complemented by an outer rainscreen made of industrial-grade perforated metal sheeting or unpainted mineral-fiber cement boards. The space between the layers serves as a thermal buffer, perhaps explaining why the construction crew nicknamed the building, although technically inaccurate, “the Thermos bottle”. This was their expression of appreciation for the overall approach to sustainable construction.
The Title 24 California Building Standards Code – a broad set of requirements for energy conservation and “green design” – does not have explicit specifications for “Thermos bottles” per se, let alone for a house heated and cooled by solar and geothermal energy. When the plans and performance-based analysis of the building envelope were submitted for the building permit, the calculation standards had to be modified as no energy was drawn from the state’s power grid and solar cooling did not exist in the system. The numbers did not add up to any passing grade, as the energy demand was too low for the spreadsheet. Despite the state’s stringent environmental policies, the ranch house stood outside the norm, even though much effort had been made to apply common-sense to building with less, and more responsibly. The public officials had to help figure out how to get the necessary approvals; illustrating the urgent need for the building codes to be updated.
The machine in the garden

Contextual and aesthetic impact
All told, construction on the ranch house proceeded experiment by experiment. As with the trial-and-error approach to site planning as well as the 99¢ Space conversion, the tests carried out on the new house attempted to push the limits of standard building products and practices alike. The land and the ranch facilities are managed as an ecosystem. Natural and constructed processes are integrated, each drawing on the other. Refugio Road Ranch is a mosaic of ideas and solutions aimed at connecting things that often remain unconnected.

Far from confirming the bucolic cliché of country life, the project reconsiders what a contemporary ranch can be as a shared habitat for humans and non-humans, and what it can do environmentally, economically, and socially as an inhabitable hybrid. Not just “a machine in the garden,” to recall another American trope examined by Leo Marx in his 1964 book of the same name, where the technical and the natural are held apart as distinct realms, the project explores ways to put their entanglement to work in mutually reinforcing loops of give-and-take.
What might once have seemed an apt diagnosis of the disharmony between a pastoral ideal and the advance of civilization, Leo Marx’s machine-in-the-garden metaphor still upheld the common view of an idyllic nature encroached upon by invasive technology. Even today, we may indeed still think unreflectively in terms of “nature” on one side and “technology” on the other. But contrary to this culturally engrained

*Logplug* by David Greene, one of the founders of the experimental architecture group Archigram, who conceived of a fully integrated technological environment, 1969.
view, the Refugio Road Ranch experiment works to reconcile polarities between the artificial and the natural, the technological and the pastoral, as well as the machine and the garden.

What results is something along the lines of David Green's *Logplug* from the late 1960s showing a working drawing of a tree trunk outfitted with mechanical installations and plugged into a subterranean infrastructural network. Here, the idea of “a full-service natural landscape” was part of a vision for a fully integrated technological environment. And this goes for the ranch as well.

Cultivating a collaboration of nature and technology through design, the project operates as an aggregate of relations and reciprocal dependencies played out in and with the existing landscape – from water pump to in-floor coils, from cistern to irrigation network, from solar panels to electrical boilers. Technology, in this respect, is not an invader of some primordial setting, but is rather a constituent part of a larger operating system, whereby the machine is the garden and the garden the machine.
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Publications in this series

Best Practice examples of sustainable construction from around the globe
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