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Sam Circle Venture

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India Concept House

A white paper on manufacturing and assembling of an affordable, quick-to-build and sustainable mass housing solution for Indian cities

December 2011

Authored by:

KIERANTIMBERLAKE

PROJECTWELL

PROJECT HISTORY

In November 2009 Sam Circle Venture approached KieranTimberlake about addressing the problem of housing in India. Having relayed India's widely quoted deficit of 26.3 million housing units, and concerns regarding resource scarcity, Sam Circle Venture described a grand challenge: "We believe that the problem requires a market-ready, affordable, quick-to-build, sustainable house." Given our architectural portfolio of high-performing US residential prototypes achieved through off-site fabrication techniques, Sam Circle Venture proposed a way forward, one which paired KieranTimberlake's design expertise with the development expertise of Projectwell, their Mumbai-based partner.

Research and design officially commenced in November 2010, and a concept was jointly explored through overseas collaboration between KieranTimberlake, Projectwell, and Sam Circle Venture. Work primarily occurred at KieranTimberlake's Philadelphia based studio with both Projectwell and Sam Circle Venture participating in program development, conceptual development, and construction systems analysis. The India Concept House, formulated as a response to this challenge, was fully depicted through project goals, drawings and a model by March 2011, when the concept design phase officially concluded.

The India Concept House, so named because it currently remains a deeply researched idea, has since been vetted with engineers and industry alike. It is conceived as both a dwelling for inhabitation, and as a process by which homes are produced through a managed supply chain. It is now poised to be prototyped and assessed in the Indian context. As such, Sam Circle Venture, KieranTimberlake and Projectwell (hereafter referred to collectively as the design team) anticipate the construction of a prototype in 2012 in order to evaluate manufacturing, delivery, and construction, and to measure the house's thermal comfort, energy and water consumption. Presently a viable operations framework for the India Concept House is being established; one developed in consultation with knowledge partners, thought leaders, and policy makers.

KieranTimberlake, December 2011

INDIA CONCEPT HOUSE INTERIOR. IMAGE PROVIDED BY KIERANTIMBERLAKE.

PROJECTWELL
www.projectwell.com

Projectwell is a third-party development management firm based in India. It currently manages a portfolio of diverse projects across India and focuses on developing solutions related to mass affordable housing, with an emphasis on planning, development, and management of building assets. Projectwell develops processes, products, and systems to address the entire building supply chain, from pre-feasibility to post-operation phases. Research and development is an inherent part of Projectwell's ethos. It is the Projectwell team's belief that without research and development, the construction industry has no future; things will remain the same as it was thirty years back. It is innovative practices which will bring in efficiencies in the industry, leading towards mass scale employment generation, lowering of input costs and upliftment of India's economy from the grass roots. The Projectwell team is capable and motivated to turn great innovations into marketable solutions which have a mass appeal and are sustainable in nature.

KIERANTIMBERLAKE
www.kierantimberlake.com

KieranTimberlake is an award winning American architecture firm established in 1984. The firm is noted for its fusion of research with architecture, receiving over 125 design citations including the 2008 Architecture Firm Award from the American Institute of Architects, and the 2010 Cooper-Hewitt National Design Award for Architecture. They are recognized leaders in sustainable design with a diverse body of work for arts, civic, educational, and government institutions, and residential clients.

Over the course of multiple projects, they have employed a range of innovative approaches to off-site fabrication to reduce cost and time, increase quality, and reduce the environmental impact of construction. They have worked with Make It Right to design a prototype for rebuilding affordable and sustainable homes for New Orleans; The Museum of Modern Art on Cellophane House™, a fully recyclable, solar powered dwelling made of transparent materials; and LivingHomes on a mid-market, off-site produced, expandable town home. The firm is currently designing the new United States Embassy in London, which incorporates several leading edge strategies to reduce energy consumption.

SAM CIRCLE VENTURE
www.samcircleventure.com

Sam Circle Venture is an intellect, capital and execution platform for advise, invest and manage services for various stakeholders keen to participate in investment and business opportunities in the growing economy of India. It is primarily focused on bringing innovations, technology and capital partners from emerged economies and critical sectors for India's social and economic growth by developing a portfolio of assets.

It is engaged in developing a portfolio of assets in education, healthcare and building technologies through its operating partners. Sam Circle Venture Partners are currently involved in various stages of planning, developing and managing a portfolio of $250 million.

PAPER ORGANIZATION

This white paper presents the India Concept House in two parts:

Part one summarizes goals for the house, its relationship to climate and associated thermal comfort; use of energy, and water; transportation and approach towards off-site prefabrication. Findings for each one of these topics are included in this section and are a result of implementing KieranTimberlake's Research and Environmental Design (RED) Report process. The RED Report process required the team to begin from a point of view of impartiality, collect and assess historical information, numerical data, maps, building code and technical specifications, in order to articulate initial strategies as the basis for a housing solution.

Part two describes the complete housing solution including its spatial arrangement, modularity and expansion, wall and roof components, their manufacture, associated construction time, delivery process and whole house anticipated environmental performance. Diagrams and drawings of the India Concept House, completed as part of the design team's concept development phase are included in this section.

INITIATING PROJECT DIRECTIVES

The India Concept House began as an idea guided by six directives. The design team anticipated that these directives would evolve into specific project goals, especially through the analysis of information gathered during the RED Report process.

Six initiating directives for the India Concept House:

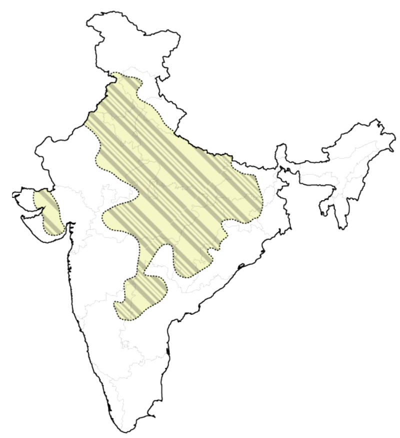
1. Provide a house at a cost of Rs. 900-1200/SF located in a Tier II or Tier III city.
2. Fabricate a reasonable percentage of a detached house for India off-site via a process executable at a mass scale.
3. Detail material and systems connections to reduce on-site construction time to four weeks.
4. Provide buyers with options for material mass-customization.
5. Meet or exceed thermal comfort goals for a house located in India's composite climate zone.
6. Meet or exceed resource conservation goals for a comparable baseline.

Of these, directive number five requires further explanation because it provided a way for KieranTimberlake to organize RED Report research and engage a research methodology. Ultimately it provided the basis for the design team to propose a climate specific house, one which resonates self-sufficiency, in addition to a quick-to-build modular construction system.

PROJECT SITE

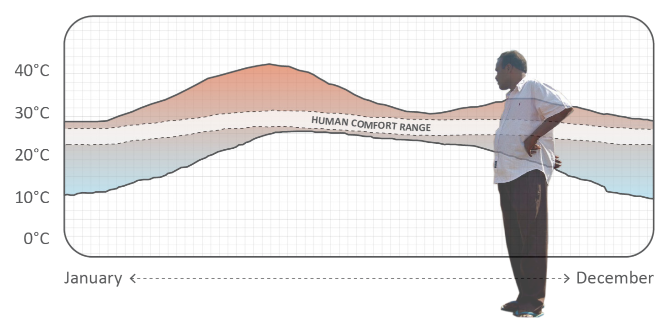
Per directive five, "meet or exceed thermal comfort goals for a house located in India's composite climate zone," the design team acknowledged that the house required a site, however broadly defined, in order for its overall form and the form of its individual components to respond to specific solar radiation, relative humidity, temperature, and wind profiles. The house equally required a site in order to challenge the assumption of access to sufficient road infrastructure and prefabrication methodologies.

The composite climate zone, chosen per directive five, as the "site" for the India Concept House, is India's largest climate zone. This zone is centrally located, incorporates seven whole states and portions of four other states. It covers India's highly populated northern region and includes the Tier I city of Delhi. The composite climate zone, defined by the 2005 National Building Code, contains aspects of all other climate zones, and changes greatly over the course of the year. On an annual basis, temperature, relative humidity and average rainfall data indicates three distinct seasons with transitional periods in-between. The first season is roughly from March to June and is characterized by hot temperatures and little to no precipitation. The second season is known as the monsoon season and brings slightly lower temperatures with the majority of all rainfall for the year and large cloud cover. The final season lasts from October to February, with temperatures getting colder, but with little to no precipitation (ISHRAE, 2005). Given the housing challenge, the size of the composite climate zone, population contained therein, and seasonal variation, the design team considered these maximal conditions for a pilot housing project site.



SEASON	TEMP. (HIGH)	TEMP. (LOW)	RELATIVE HUMIDITY	AVG RAINFALL
Hot & Dry	43°C	28°C	20-25%	35mm
Hot & Humid	34°C	21°C	55-95%	900mm
Cool & Dry	25°C	5°C	20-25%	50mm

INDIA'S COMPOSITE CLIMATE ZONE. DIAGRAM BY KIERANTIMBERLAKE.



THE HUMAN COMFORT RANGE IN THE COMPOSITE CLIMATE ZONE. DIAGRAM BY KIERANTIMBERLAKE

RESEARCH METHODOLOGY

In order to establish climate and location specific resource conservation and construction goals, 11 cities located in the composite climate zone were selected for further study. Together, these 11 cities provided a cross section of data while limiting the scope of research to a manageable effort. This grouping of cities was determined based on four additional criteria: population, climate data availability, transportation access, and state affiliation.

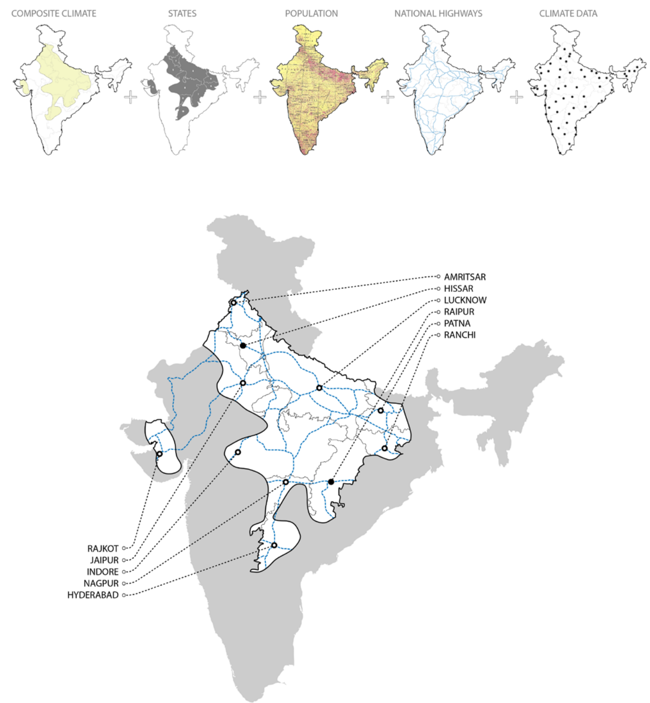
Composite climate zone cities with a population less than 5 million people, and thus classified as either Tier II or Tier III qualified for further research. If a city's climatic data could be accessed as a TMY2 data set issued by ISHRAE through the US Department of Energy, then it qualified for additional research. Cities located along a national highway ensuring transportation access again qualified for further research. Finally, of the remaining cities, the team selected one per state comprising the composite climate zone, ensuring a varied cross-section assessment of data throughout the RED Report process.

During the India Concept House's design phase, data aggregated from each city allowed the team to, for instance, assess solutions for effective active and passive cooling and heating strategies; anticipate adapted thermal comfort; evaluate the integration of primary and renewable sources of energy; estimate energy use and on-site energy generation potential, and evaluate weight and dimension of construction system components.

Summarized herein are RED Report assessments and associated goals for the following topics:

1. Thermal comfort
2. Energy
3. Water
4. Transportation
5. Existing off-site fabrication methods

Each one of these topics is critical to providing a "market-ready, affordable, quick-to-build, sustainable house." Similarly assessed in the design team's final India Concept House RED Report are the topics of target market, Indian housing typologies, familial room use patterns, development incentives, flood potential, seismic risk, air pollution, water pollution, solid waste infrastructure, labor, traditional material use per state, general material availability, and the IGBC Green Homes Rating System.



THE COMPOSITE CLIMATE ZONE AND TIER II AND TIER III CITIES SELECTED PER STATE, POPULATION, NATIONAL HIGHWAY ADJACENCY, AND CLIMATE DATA ACCESS. DIAGRAM BY KIERANTIMBERLAKE.

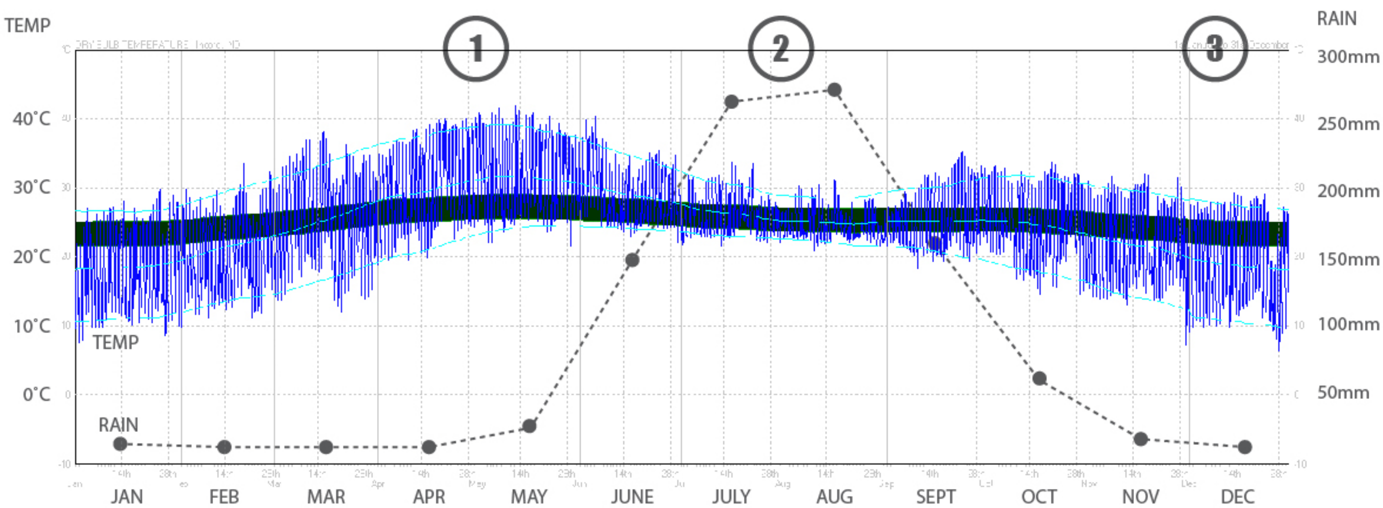
1. THERMAL COMFORT ASSESSMENT AND GOALS

A thermal comfort assessment for the 11 selected cities determined passive and active strategies for the India Concept House critical to ensuring occupant comfort, designing building form, and managing energy and water consumption. This RED Report topic first required a psychometric climate analysis for each city to determine the zone's climatic coherency.

Psychometric analysis indicates a consistent zone, despite the significant distance separating the cities (ISHRAE, 2005). The overall trend found in the psychometric charts is a climate that over course of a year transitions from hot, to hot and humid, and ends cool and mild with relatively little humidity. There is a slight variation at the extreme temperatures within this pattern, as some cities experience higher peak and lower minimum temperatures.

Effective climatic strategies derived from this analysis are the use of natural ventilation and thermal mass. Natural ventilation appears most effective at providing inhabitants comfort on days in which both the temperature and the humidity are high, which happen relatively frequently. Thermal mass is effective when the temperatures are high but both humidity and temperatures are low. Through the application of these two strategies a significant improvement in the overall comfort of the building inhabitants can be realized.

However, even with the full and successful application of passive strategies, a significant number of data points remain that are either too hot or too cool to be alleviated solely with passive strategies and require active measures. The design team anticipates that cooling strategies will be needed to maintain comfort; analysis likewise indicates that heating strategies are required in a number of the selected cities. House cooling and heating needs are not, however, so severe as to require large mechanical units, as temperatures are not too far removed from the point of thermal comfort.



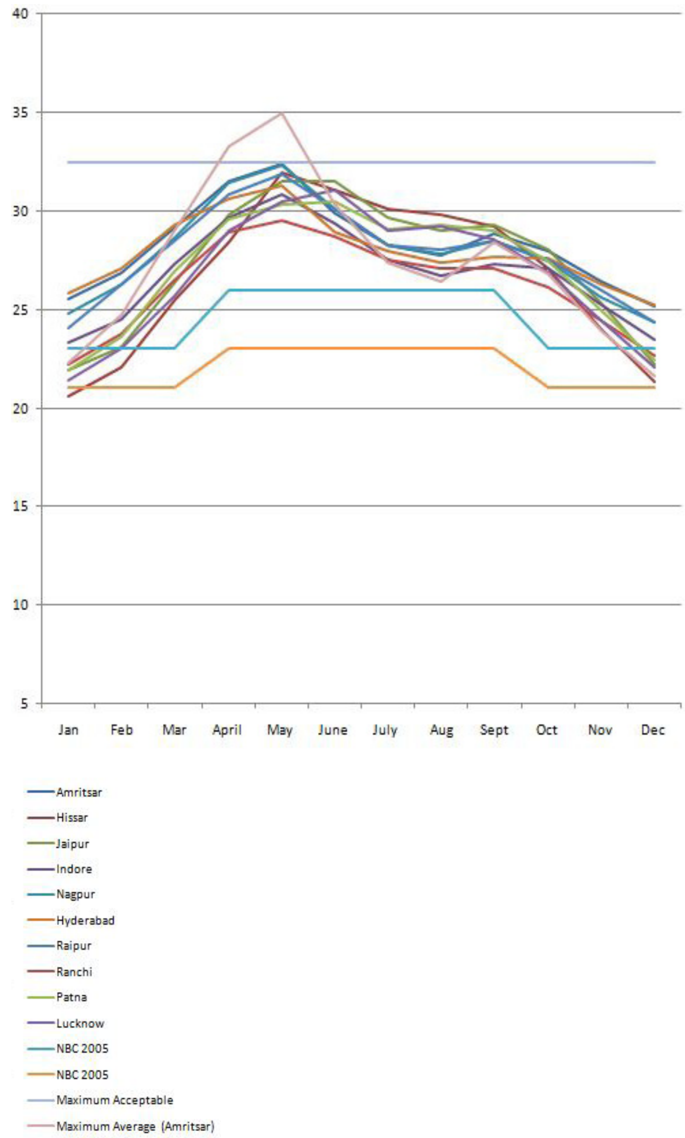
EXAMPLE DRY BULB TEMPERATURE COMPARED TO RAIN LEVELS FOR THE CITY OF INDORE, INDICATING HOT AND DRY, RAINY AND HUMID, AND COOL AND MILD SEASONS. DIAGRAM BY KIERANTIMBERLAKE.

1. THERMAL COMFORT ASSESSMENT AND GOALS (CONT.)

Given the design team's directive to meet occupant thermal comfort needs and reduce resource consumption, published research literature was reviewed on the topic of thermal comfort. Though literature in the Indian context was limited, two articles informed goals for the India Concept House. Professor Indraganti, of Princess Nora University, Riyad, Saudi Arabia conducted a comfort survey in the summer in Hyderabad and found the National Building Code of India specified temperature comfort band was too constrained relative to the occupant's actual comfort thresholds. The Hyderabad study reveals a temperature bias dependent upon socioeconomic status, with personal wealth inversely correlated with temperature accommodation. In the Hyderabad study a temperature comfort band of 26-32.5°C was found for all occupants (Indraganti, 2010, pp. 866).

The Indraganti study was cross referenced with "Adaptive thermal comfort and sustainable thermal standards for buildings" by Nicol and Humphreys of Oxford Brookes University. This study reviews thermal comfort requirements for building occupants as a general concept, substantiated by findings in a number of climate locations. The conclusion of the analysis supported an adaptive thermal comfort model, one that fluctuates with the average monthly outdoor temperature. The basic formula for the target thermal comfort temperature in any given month is $T_{comfort} = 13.5 + .54\ T_{monthly\ mean}$ (Nicol and Humphreys, 2002).

An analysis of the 11 target cities in the composite climate zone using the above formula corroborates the Indraganti study findings with comfort temperature not exceeding 32.5° Celsius; however the temperatures do significantly exceed the National Building Code temperature comfort band during all seasons. This analysis also indicates the most challenging months for maintaining comfort will be in May and June, with average temperatures in excess of 35° Celsius possible in some cities. The analysis indicates that acceptable temperatures are quite high, but not as high as the average temperatures found in composite climate. The India Concept House, at the peak of the day may experience ambient temperatures in excess of the thermal comfort target, requiring the design team to integrate active thermal comfort technologies.



ADAPTIVE ANNUAL THERMAL COMFORT PER CITY, COMPARED TO THE 2005 NATIONAL BUILDING CODE RECOMMENDED THERMAL COMFORT BAND. CHART BY KIERANTIMBERLAKE.

THERMAL COMFORT GOALS:

Design for India's composite climate's monsoon, summer and winter seasons.

Monsoon: House openings and internal objects between openings provide zero resistance to cross ventilation.

Summer: Internal surfaces receive zero direct solar radiation during the day and flush heat at night.

Winter: Internal surfaces receive 100% direct solar radiation and store solar energy as thermal mass.

Achieve thermal comfort irrespective of site orientation, and permit inhabitation of exterior spaces during all seasons.

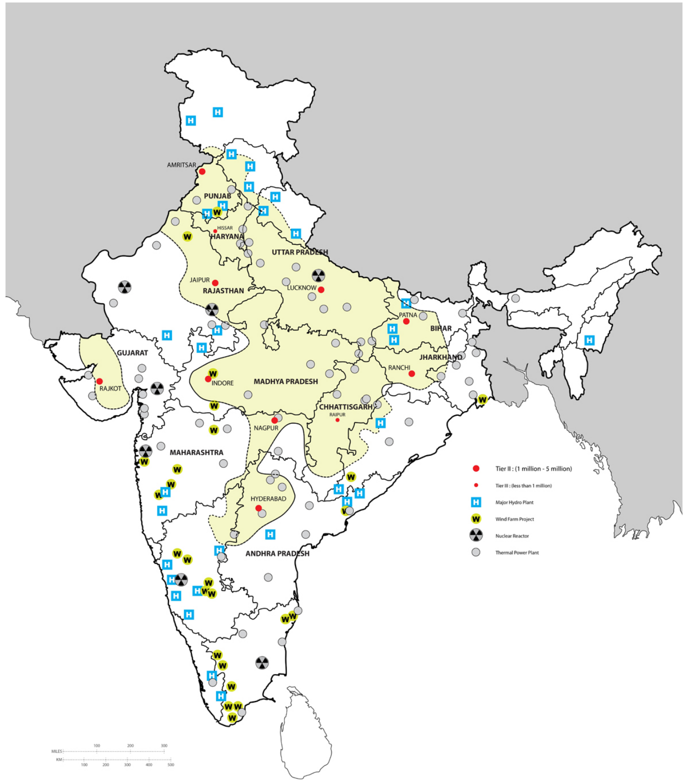
2. ENERGY ASSESSMENT AND GOALS

India Concept House inhabitants may consume, in a 98 m2 house, between 31.3 to 41.2 kWh of power per day, or 11,141 to 15,028 kWh per year. This estimate is based on anticipated lighting loads, plug loads associated with several small appliances such as a toaster or radio and plug loads associated with fans. Large loads are primarily concentrated in the kitchen, utility/laundry area, and living room. A range is anticipated based on the ability to eliminate air conditioning entirely, and provide an alternate fuel source for the house's central stove.

The primary energy sources available in the composite climate zone to meet this power demand is grid supplied and generated via coal fired thermal power stations. Exceptions to this exist in the states of Bihar, Uttar Pradesh, Madhya Pradesh, Rajasthan, and Punjab, which have small concentrations of nuclear reactors, hydro plants and wind farms. The fuel mix within the composite zone is considerably more dependent on thermal production than the rest of the country (Maps of India, 2010).

Energy supply is inconsistent. The US Energy Information Administration estimates that 66% of the country is without electricity; blackouts are a common occurrence throughout the country's main cities. Compounding these issues, India's electrical demand continues to outpace its growing capacity. In addition, coal shortages are putting strain on power generation capabilities (EIA, 2011). Energy supply for the house's central stove is an exception to the use of grid supplied energy. Approximately 50% of households use liquefied petroleum gas (LPG) for cooking fuel, the remaining 50% of households use a mix of less clean fuels that include coal, wood, dung, and kerosene (Ministry of Home Affairs, 2011).

On-site energy generation is as option for house owners. Primary sources of reliable on-site energy generation for a single-family house in India are solar thermal and solar photovoltaic (PV) systems. For solar thermal systems a thermosyphon system would provide the most self-sufficient solution as it requires no electrical pumps. These systems can achieve hot water capacities of 100-150 liters per day with a collection plate area of 2 m^2 (Nayak and Prajapati, 2006). PV systems should be considered as a way to offset the use of grid sourced energy and/or as a back-up power system for power outages. The most likely PV system to fall within the India Concept House budget is a solar home system. These systems consist of an assortment of PV panels, batteries and electrical hook ups that may be used to support small loads including fans and plug-in appliances. (Nayak and Prajapati, 2006). Large PV arrays are presently less applicable because of their high costs and because no net-metering policy has been found in India that would allow users to fed excess energy back into the grid.



TYPES OF POWER GENERATION SOURCES PER STATE, AND PER THE COMPOSITE CLIMATE ZONE. DIAGRAM BY KIERANTIMBERLAKE BASED ON INFORMATION COMPILED FROM MAPS OF INDIA, 2010.

ENERGY GOALS:

Eliminate air conditioning.

Supply electricity for primary and back-up systems without grid energy.

Supply hot water without grid supplied energy.

3. WATER ASSESSMENT AND GOALS

India Concept House residents are estimated to demand, in a 98 m^2 house, 288 liters of potable water, 252 liters of non-potable water, and 80 liters of hot water daily. Potable water use includes water for drinking, cooking, bathing and washing clothes and utensils. Non-potable water use includes toilet flushing and gardening. Hot water use is for bathing.

Water may be supplied from state municipalities. Liters of water used daily by individuals vary greatly from one state to the other. The difference can be as great as 50%, indicating that either citizens in one state have vastly different water use patterns than citizens in another state, or there is a severe water shortage in some states (Gautam, 2009). Both may be true, however, more weight is given to the likelihood of water shortage due to a World Bank report on India's water economy issued in 2006 (Briscoe, 2006). In the report, the amount of water storage capacity per person country-wide in India is found to be 200 cubic meters, compared to other middle income countries like South Africa, China, Mexico, and Morocco, which store over 1000 cubic meters per person. Thus, India's country-wide storage capacity is equivalent to approximately 30 days of use (Briscoe, 2006, pp. XV).

Municipal water delivery is frequently disrupted. Water may be supplied for a limited number of hours per day. For instance, water is supplied to Amritsar, Nagpur, and Rajkot, selected cities in the composite climate zone, 11, .95 and .3 hours per day respectively (Asian Development Bank, 2007). Country-wide, water consumers are moving towards tapping private wells and using groundwater which accounts for 80% of domestic water used and in many areas is close to being exhausted (Briscoe, 2006, pp. XVIII). Those that receive state supplied water have a strong incentive to store water, which places further stress upon available water resources. Aside from irregular supply, there are continued issues with water pollution, both from ground water and municipally supplied water, which requires homeowners to install purification systems (State of the Environment: Atlas of India, 2010).

If a 30 day supply is similarly available in the composite climate zone, and municipal supply continues to be disrupted, India Concept House residents will need other sources of water, such as on-site rainwater collection and gray water recycling in order to meet demand. Rainfall may be captured and stored on site, but is unlikely to consistently meet the total demand because its collection is dependent on the monsoon season. On-site rainwater collection, storage and use are very common and accepted practices. Rainwater collection systems are frequently owner constructed and deployed using available materials. There are no government regulations regarding rainwater storage, but the practice is both acknowledged and actively encouraged by the Department of Drinking Water Supply (Ministry of Rural Development: Department of Drinking Water Supply, 2000; Tripath, 2000).

Recycling of gray water for non-potable uses is a common and accepted practice, particularly in rural areas. A manual for the implementation of gray water systems was released by the National Environmental Engineering Research Institute, and has been the subject of workshops sponsored by the Department of Drinking Water Supply (National Environmental Engineering Research Institute, 2007; Rajiv Gandhi National Drinking Water Mission, 2008).

State	Daily water supply per capita in liters
Rajasthan	115
Madhya Pradesh	93.77
Mharashtra	106.74
Andhra Pradesh	78.88
Chahattisgarh	90.15
Jharkhand	118.31
Bihar	120.56
Uttar Pradesh	127.77
Gujarat	130.45
Punjab	177.31
Haryana	91.32

DAILY WATER SUPPLY PER PERSON PER DAY IN SELECTED STATES. CHART BASED DATA COMPILED FROM GAUTAM, 2009.

City	Percent	Hours
Amritsar	75.7	11
Nagpur	91.5	.95
Rajkot	98.1	.3

PERCENTAGE OF RESIDENTIAL WATER ACCESS VIA PUBLIC TAP OR HOUSE CONNECTION AND ACCESS HOURS PER DAY. CHART BASED ON DATA COMPILED FROM GAUTAM, 2009.

WATER GOALS:

Manage 100% of the storm water on site.

Collect, store, pressurize, supply, filter and recollect potable water to achieve short-term water self-sufficiency.

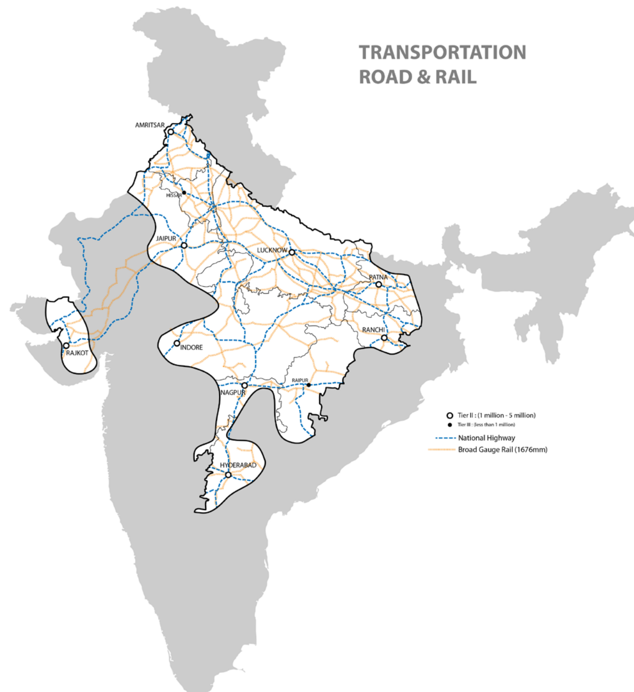
4. TRANSPORTATION

The India Concept House may be delivered to its site for assembly via India's roadways, a network that can be broken down into three categories: (1) National Highways; (2) State Highways and Major District roads; and (3) Rural roads (Planning Commission: Government of India, 2008). The road network, as of 2011, comprises 70,934 km of National Highways, 131,899 km of State Highways, 467,763 km of Major District Roads and about 2.65 million km of Rural and other roads. Though National Highways account for only 2% of the overall road infrastructure, they are responsible for over 40% of annual total road traffic, making them heavily used. Likewise, the secondary system carries another 40%, leaving a minority of traffic to the rural road infrastructure. However, since the India Concept House is targeted to Tier II and Tier III cities, the state of secondary and rural road conditions are of critical importance to understand (NHAI, Dec 2011).

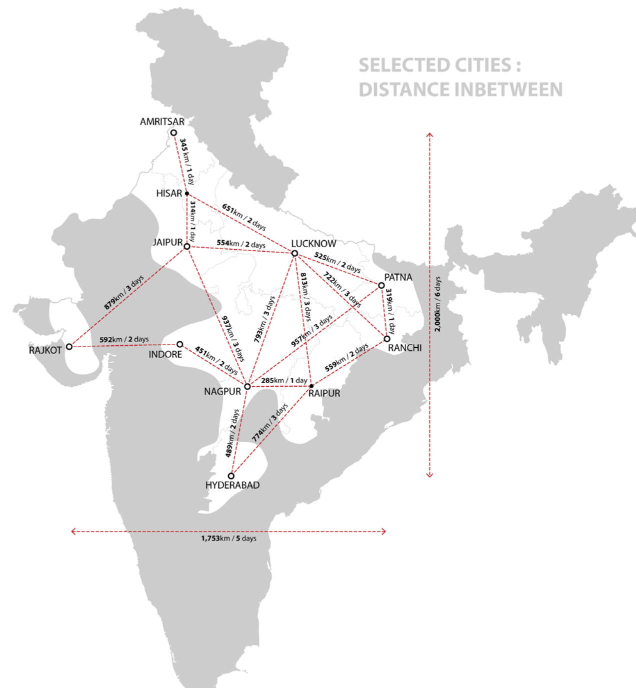
The National Highway system is in the process of being updated via the National Highways Development Program (NHDP). The NHDP was implemented in 1998 as a way to connect the entire country by four lane highways. The Project is composed of four different groups of highways, the Golden Quadrilateral, the North-South Corridor, the East-West Corridor, and Port Connectivity. The Golden Quadrilateral acts as a large scale loop, creating a ring connecting many of the major cities, such as New Delhi, Kolkata, Chennai, Bengaluru, Mumbai, Ghandhinagar, and Jaipur. As of November 30th 2011, a total of 5,846 km of the Golden Quadrilateral plan has been converted into 4 lane highways. Currently completing work in Phases II to IV, the NHDP is working on the North-South Corridor, which runs the entire length of the country, connecting Srinagar in the north to Thiruvananthapuram in the south, and the East-West Corridor, which connects Rajkot in the west to Guwahati in the east (NHAI, Nov 2011).

The rural roads in India have likewise been targeted for improvement and expansion. In 2000, the Government of India along with the World Bank launched the Pradhan Mantri Gram Sadak Yojna (PMGSY), which sought to upgrade about 372,000 kilometers of rural road infrastructure to connect almost 180,000 habitations (The World Bank). The aim is to provide all-weather road connection to habitations above a population of 1000 (500-plus for hilly and tribal areas). As of 2007, 100,000 kilometers of new roads have been constructed, though 35% of the inhabitations have yet to be connected by all-weather roads (Planning Commission: Government of India, 2008).

Successful implementation of an off-site manufacturing process is dependent on a high-quality road network. Future road network infrastructures will greatly impact where the India Concept House is manufactured, the number of manufacturing centers, estimated time of delivery, and number of cities with access to the product.



RAIL AND ROAD INFRASTRUCTURE IN THE COMPOSITE CLIMATE ZONE. DIAGRAM BY KIERANTIMBERLAKE.



DISTANCES BETWEEN SELECTED TIER II AND TIER III CITIES IN THE COMPOSITE CLIMATE ZONE. DIAGRAM BY KIERANTIMBERLAKE.

TRANSPORTATION GOALS:

Design house components with a target weight that allows them to be transported.

Locate house manufacture adjacent to viable road infrastructure

5. EXISTING INDIAN OFF-SITE PREFABRICATION

Implementation of the India Concept House is contingent on consumer acceptance of an off-site prefabrication approach to house construction. While information on the Indian prefabrication industry is limited, available information suggests that an emerging market is targeting middle class consumers.

The longest running identified prefabricated home company is Hindustan Prefab limited, a government subsidized company that has been producing prefabricated buildings since the late 1960s, usually for commercial applications (Hindustan Prefab Limited, 2011). Recently a number of companies have begun offering prefabricated housing products. The majority, if not all, offer attached housing in the form of apartments or condominiums.

Current market-available products address prefabrication through multiple methods, resulting in varying amounts of on-site construction. Two companies surveyed deliver a proprietary supply of individual building products on-site resulting in 100% on-site construction; three companies deliver prefabricated panels on-site resulting in an estimated 30% off-site and 70% on-site construction. Two additional companies surveyed deliver whole prefabricated rooms resulting in an estimated 80-90% off-site and 10 – 20% on site construction. Estimates of the time associated with on-site construction per system were not discernible. Each approach has implications for the use or disuse of material handling equipment, the amount of off-site versus on-site skilled labor, and the type of road infrastructure required for transport. Each system used cement, either as an ingredient in precast or site cast concrete, or as an ingredient in a board product.

OFF-SITE AND ON-SITE FABRICATION GOALS:

Construct 90% of the house off-site and 10% of the house on-site.

Achieve a high-quality finish product.

Minimize the time needed for on-site systems integration.

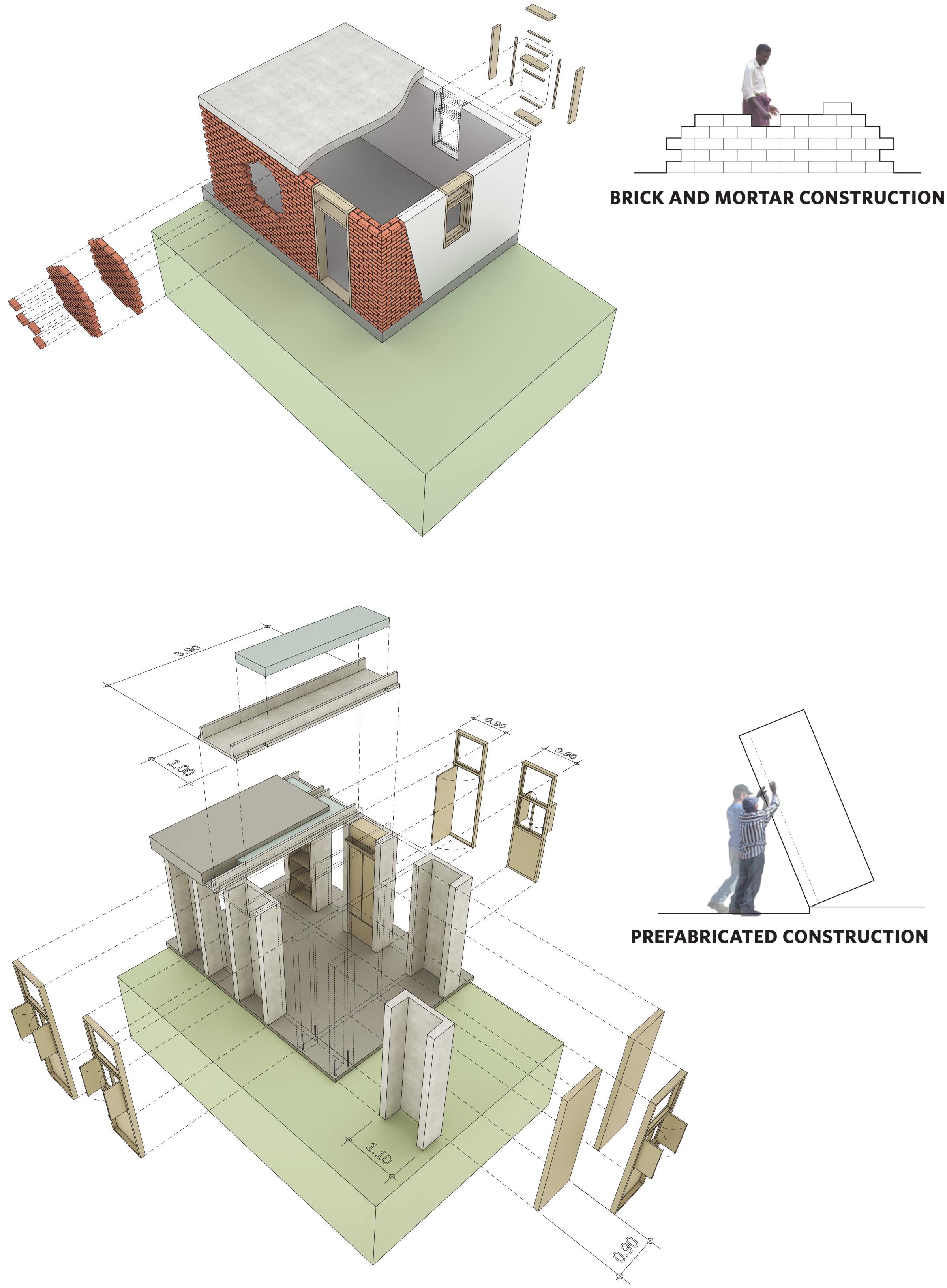
Achieve on-site construction in less than six weeks.

Eliminate the use of on-site material handling equipment.

Design house components with a target weight that allows them to be carried manually.

Company	Units/Year	Unit Size	Cost /Unit	Cost (Rs.)	Location	Construction Type	Partner
Holland India Housing	1000	1200-2400	—	—	South India	Precast Concrete	None
Trigunass Build Tech 1	6700	250-700	444,400-666,650	1,150	—	Formwork+lightweight concrete	Plastek (Malaysia)
Trigunass Build Tech 2	1904	350/450/620	500,000-1,111,100	1,400	Bangalore	Formwork+lightweight concrete	Homex (Mexico)
Puravankara Projects	—	42-818	555,550-1,111,100	1,250	Chennai	Aluminium molds w/ concrete	None
VBHC	1900	—	500,000-1,111,100	—	Chennai Hyderabad, NCR	Aluminium molds w/ concrete	Company in Kansas city
Brigade Group	1 million SF by 2011	400-1,100	800,000	2,000-2,650	—	Precast concrete	Subarna International

COMPANIES OFFERING PREFABRICATED SOLUTIONS IN THE INDIAN MARKET. CHART BY KIERANTIMBERLAKE.



INDIA CONCEPT HOUSE, ON-SITE ASSEMBLY APPROACH AS COMPARED TO CONVENTIONAL CONSTRUCTION PRACTICES. DIAGRAM BY KIERANTIMBERLAKE.

INDIA CONCEPT HOUSE

The India Concept House is proposed as a logistical and environmentally responsible residence of concrete construction. The house is now described per the initial challenge as an "affordable, climate specific, solid, self-sufficient, prefabricated housing solution for India's Tier II and Tier III cities." Owners may choose to expand their house; they may manage thermal comfort, both actively and passively; they may increase self-sufficiency in the likely event of water and energy scarcity.

Unlike competing systems, the India Concept House is proposed as a holistic solution that leverages established materials knowledge in order to satisfy a market for pukka construction. It appears solid and permanent to sight and touch, and as such is similar to other Indian houses. It is, however, a clear departure from traditional Indian pukka construction. The house is engineered, designed for off-site manufacture, delivery, and on-site assembly. Similar to automobile manufacture, India Concept House roof and wall components may be manufactured in a factory, which in turn, integrate with components from selected partner manufacturers.

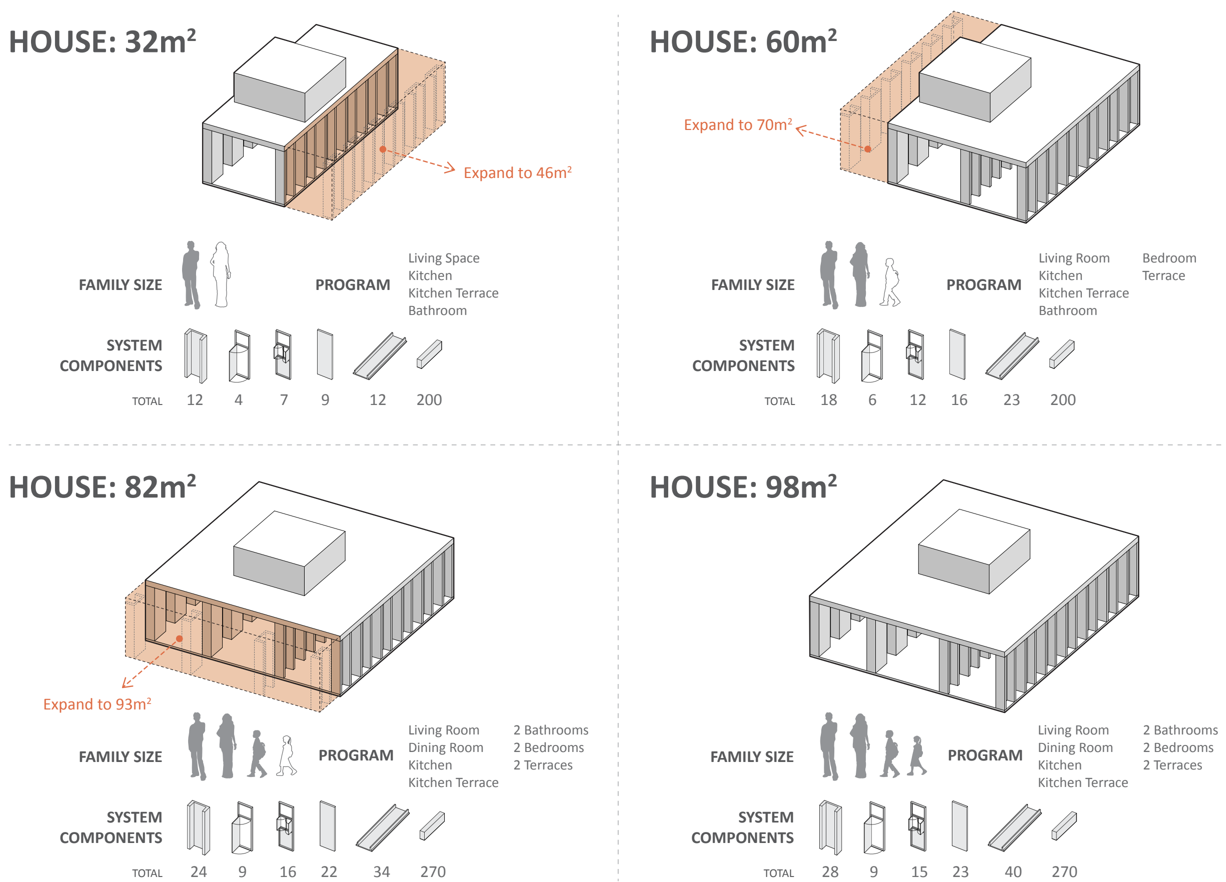
The India Concept House is currently planned in 32, 60, 82 and 98 m^2 increments, its modular component system facilitating expansion. The design is presently scalable horizontally from a one-room house to a four-room house. The design team is currently exploring the house's vertical expansion.

CURRENT PROJECT DIRECTIVES

The India Concept House is now guided by ten directives which will evolve into goals to be tested during its prototype development phase:

Ten current directives for the India Concept House:

1. Fabricate a reasonable percentage of a detached house for India off-site via a process executable at a mass scale.
2. Engineer a housing system, scalable both vertically as well as horizontally.
3. Detail material and systems connections to reduce on-site construction time to four weeks.
4. Provide buyers options for material mass-customization.
5. Meet or exceed thermal comfort goals for a house located in India's composite climate zone.
6. Meet or exceed resource conservation goals per the 2009 IGBC Green Homes Rating System
7. Provide a house at a cost of Rs. 900-1200/SF located in a Tier II or Tier III city.
8. Set up a supply chain for assembly, material supply, and worker training.
9. Address issues related to loans, funding and policies.
10. Prepare a workable business plan which incorporates on-the-ground realities.



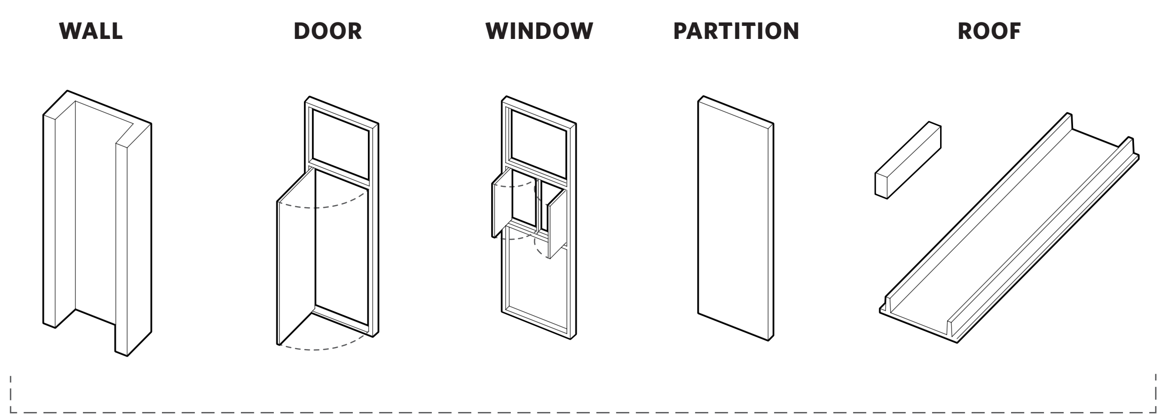
INDIA CONCEPT HOUSE, SYSTEM EXPANSION. DIAGRAM BY KIERANTIMBERLAKE.

PANELIZED BUILDING COMPONENTS

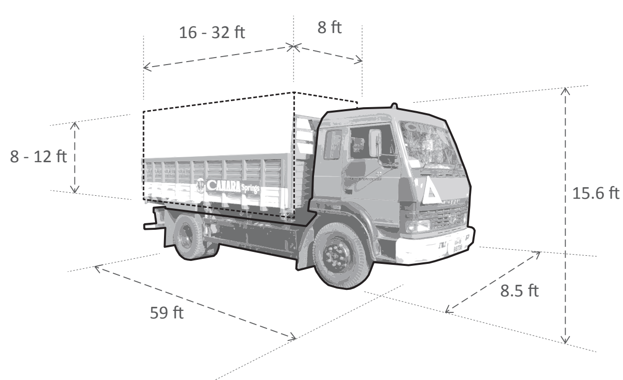
The India Concept House is based on a modular component construction system which relies on precast concrete technology to provide solid, durable, prefinished panels for painting or tiling, and if desired, eliminates finishing entirely. The primary structural component, a concrete wall panel, is shaped to self-shade in eastern and western orientations, and on the interior provide storage closets or utility integration points. Infill between the primary structural shapes may be a solid concrete panel, a lightweight aluminum door panel, or a lightweight aluminum window panel. The primary roof component, a lightweight concrete plank, is shaped as permanent formwork for the site-cast concrete roof. The secondary roof component, a precast concrete block, is used to assemble the ventilation system. Electrical and plumbing services are installed on-site, integrated into the slab-on-grade foundation system, or may be installed off-site integrated at the factory into house components.

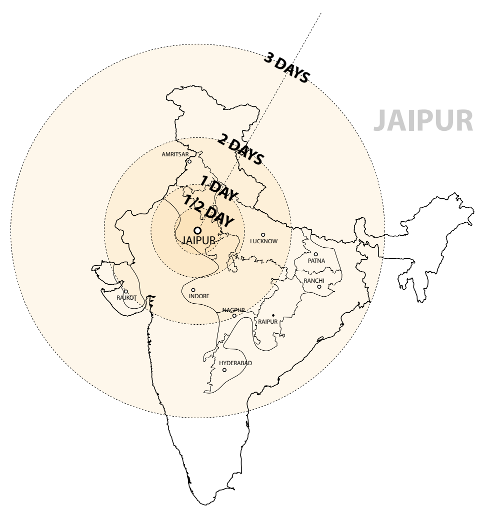
QUICK-TO-BUILD

The India Concept House may reduce on-site construction time by 90%. Its modular construction system enables a 32 m2 home to be built in an estimated four weeks. A 98 m2 home may be built in an estimated six weeks. The components are dimensioned to be easily transported and physically manageable, eliminating the need for material handling equipment. On-site building methods minimize waste and increase worker safety. Future off-site methods will eliminate waste entirely to meet an ultimate zero waste goal. In order to deliver the house to its site Indian truck sizes, carrying capacity, height of bridges, average distance travelled in a day, width of roads, and costs, were analyzed to arrive at panel dimensions and the ability of a factory to serve a catchment area.



ICH CONSTRUCTION SYSTEM COMPONENTS. DIAGRAM BY KIERANTIMBERLAKE.



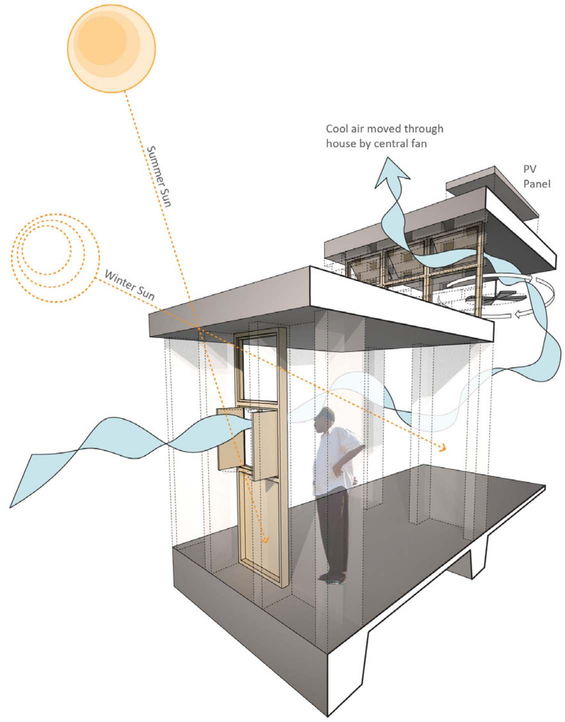


TRANSPORTATION CONSIDERATION AND DELIVERY ESTIMATIONS. DIAGRAM BY KIERANTIMBERLAKE.

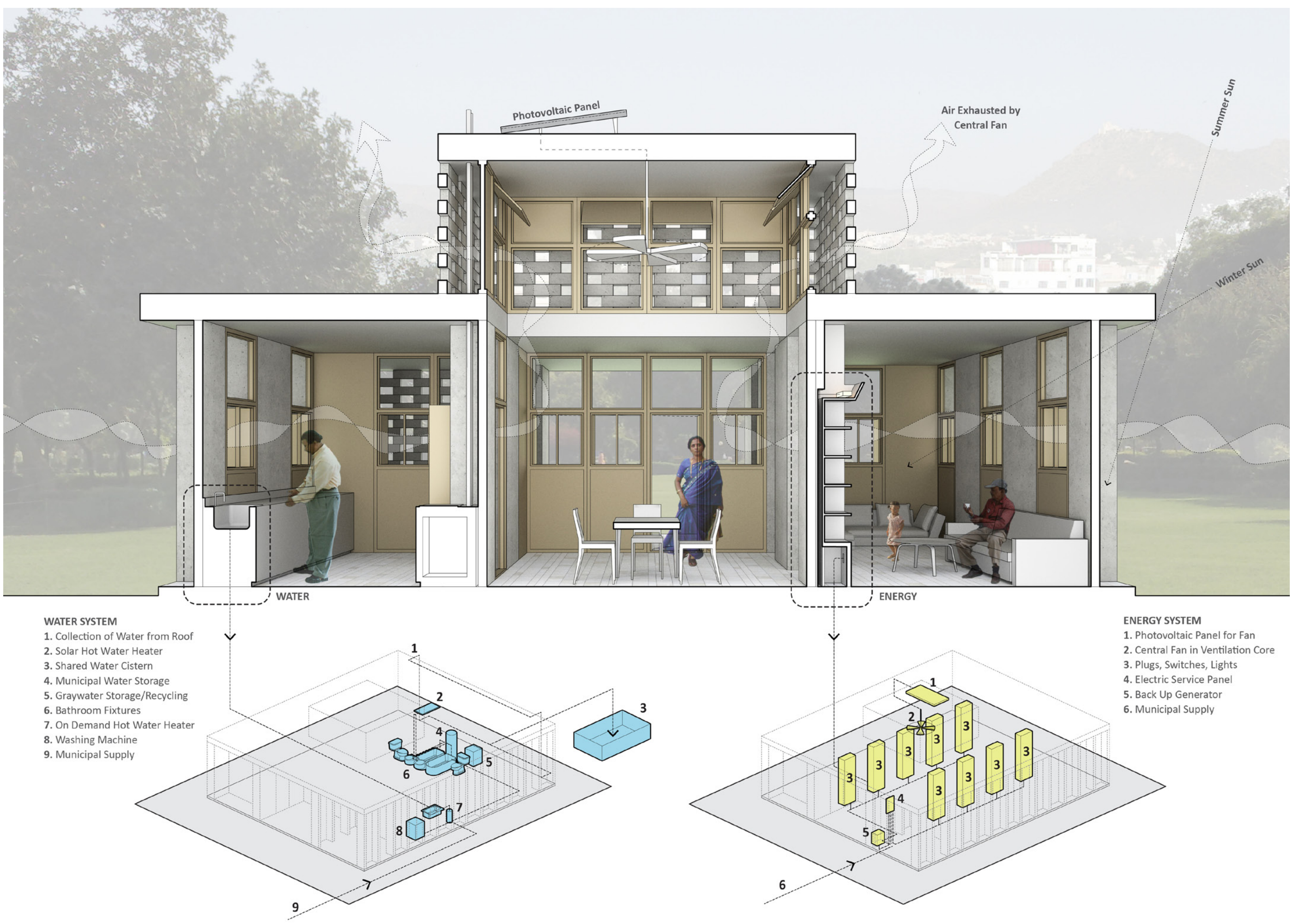
SUSTAINABLE AND SELF SUFFICIENT

The India Concept House is designed to reduce energy usage by 50% through passive and active strategies. It achieves thermal comfort without reliance on fossil fuels throughout India's composite climate monsoon, summer and winter seasons. The house responds to this wide range of seasonal variation by minimizing solar gain through overhangs and shading during the summer, encourages air movement through a central ventilation core for cooling during the monsoon season, and minimizes air infiltration during the winter. Thermal comfort is maintained irrespective of solar orientation, with an interior temperature range between 21 to 29 degrees Celsius without the use of consumptive heating and cooling systems.

To address scarcity and low quality of water, India Concept House provides a means of harvesting and recycling gray water to increase the availability of potable water to 24 hours/day. The energy required to power the active ventilation system is supplied via a photovoltaic module, and hot water is supplied using a rooftop mounted solar hot water heater.



INDIA CONCEPT HOUSE, NATURAL VENTILATION AND SOLAR SHADING STRATEGY. DIAGRAM BY KIERANTIMBERLAKE.



ICH WATER AND ENERGY SYSTEMS. DIAGRAM BY KIERANTIMBERLAKE.

EFFICIENT TO DELIVER

The India Concept House delivery process is proposed to include the following organizations/entities to deliver the house smoothly:

MANAGEMENT COMPANY: This will manage and run the business. Amongst other responsibilities, it will take care of R&D, supply chain development, training, systems and processes, and marketing.

PANEL MANUFACTURERS: Given the geography of India, several manufacturing sites will be set up, licensed to manufacture panels.

SUPPLY CHAIN: The supply chain will include various component manufacturers. Most of these are existing manufacturers, who will become part of the ICH network.

THE ASSEMBLER: The assembler will be an extension of the panel manufacturer. Working at a local level, the assembler will collate all goods from the panel manufacturer and the supply chain and construct the house.

CUSTOMER SUPPORT: Customer support at the local level serves as the point of sale and is also the source of after sales support for operations and maintenance.

INFORMATION TECHNOLOGY: All components are tied together by a very robust IT system, enabling seamless sales, delivery and after sales service. In years to come, it will be possible for one to order a house from a handheld device.

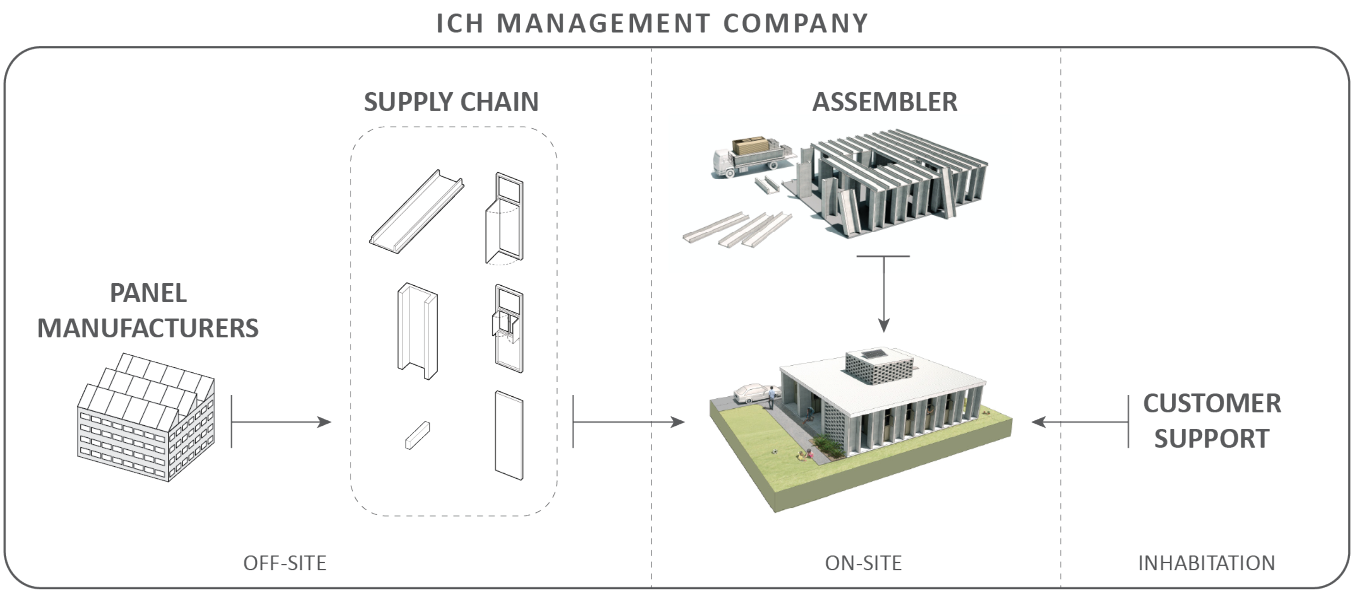
A WAY FORWARD

The India Concept House is an opportunity to address India's severe housing shortage and re imagine residential construction practices, while implementing strategies for sustainable development. The India Concept House is also a residence designed to increase an owners self-sufficiency.

The House is intended to be implemented as a product, and requires a business model that is scalable. It is also intended to stimulate others to innovate and engage this grand challenge. Its delineated process of delivery, construction and performance, may engage existing industry and policy makers alike.

The purchasing process is equally important. By providing an end user "ease" of owning a home as a single point of contact, the India Concept House departs from the current paradigm; one where an end user has to deal with multiple agencies to acquire a home. It proposes to simplify the existing process.

The India Concept House is only the beginning of an idea that attempts to address India's severe housing shortage from collective technological, social, and commercial angles. The design team's next step is to prototype the house, test the manufacturing, delivery and on-site construction sequence, and measure its performance via on-site monitoring of achieved thermal comfort, energy and water consumption.



THE ICH DELIVERY PROCESS. DIAGRAM BY KIERANTIMBERLAKE AND PROJECTWELL.

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