House of the

IPRO 301 – Spring 2006

Final Report

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Introduction

In 1983, a group of students from the Institute of Design at Illinois Institute of Technology began work on a project that described what a house of the future would entail. This team ended up winning the grand prize (10,000,000 yen) at the first International Design Competition held in Osaka, Japan because their creative and innovative ideas about how a house of the future should be built

22 years later, in 2005, IIT's Interprofessional Projects program started the Sustainable Village Project, an endeavor to build a sustainable and environmentally-aware community on the IIT campus. Part of this project was to design the house of the future in such a fashion as would fit in with the Sustainable Village.

Through use of research both in the 1983 House of the Future, as well as the House of the Future developed in the spring of 2005, this semester IPRO 301 – Back to the House of the Future had the task of establishing a system of ideas and concepts which could be globally integrated to change the way modern housing is viewed and approached by builders and residents alike.

Instead of simply being a structure that disrupts the environment and depletes natural resources, the house of the future will allow for the building of units which can be integrated into the environment and are more sustainable and efficient. By developing a methodology based on next-generation design principles, key technological advances, and considerations for building regulations and human health and safety concerns, IPRO 301 will lay a universal framework for constructing Houses of the Future of all shapes and sizes.

Cultural and Environmental Considerations

In the past few years we have seen multiple devastating natural disasters; Pakistan and Indian earthquakes, typhoons in East Asia, and devastating hurricanes affecting Central America and the US. Compounding problems posed by such catastrophes, overpopulation is rapidly becoming a problem in many sectors of the world. The global population has risen to 5.9 billion in 1998 from 2.6 billion in 1950, and is projected to rise to 9.1 billion by 2050. The US currently has a population density of 29.5 people per square kilometer, while other countries such as Macau and Maraco have respectively 24,143 and 16,410 people per square kilometer.

Given the threat posed by natural disasters, as well as increases in the number and complexity of problems stemming from population density, housing is seeing an ever-increasing need to become more stable and secure. When designing the theoretical framework for the House, IPRO 301 considered these issues at every stage of design and development. While designing a house that could stand up to extreme environmental conditions on a global level, we also sought to make it flexible, affordable, and long-lasting. By making the House flexible, we enable it to be built alongside current homes without disturbing the existing structures, and by making it affordable we allow for construction in deteriorated city sectors as a way to facilitate the reconstruction of those areas.

The following report will detail the design of the house and its internal systems. It will also cover the transportation and building process associated with the structure. Safety considerations will be outlined due to the importance of their consideration in determining systems that would work with the user and the environment while at the same time providing an element of safety.

A model of the ~~high density~~high-density floor plan.

Frame and Structure

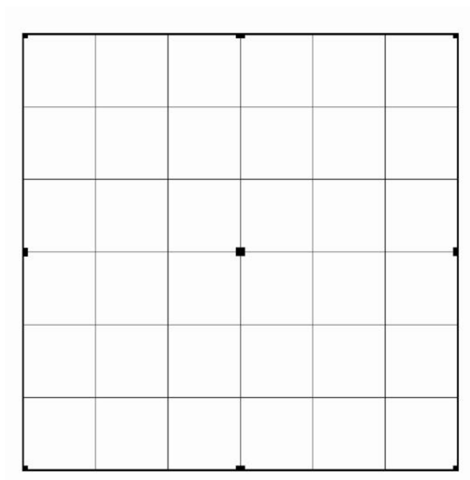
Modular design

Today we can no longer afford to work with handmade products wherein the proportion of a component is fixed but sizes vary. In order to accommodate an interchangeable, cost effective, and mass manufactured house, modern technology demands that products be produced at fixed sizes.

The module does not determine the appearance of the building, but provides a dimensional framework for its construction like making cross-stitch embroidery. Any design concept used to enclose space requires continuity of both structure and enclosure. The various part of the building must fit together according to mathematical relationship determined by a designer.

IPRO 301 elected to use a four-by-four-by-four foot dimension scheme for its modular components. These modules will provide an initial design ~~element which~~element, which will determine the placing of all units within the house. This means that all doorways and corridors within the house will be roughly 4’ in width, and many features of the house will incorporate 4’ dimensions.

Structural support
Vertical load transfer supports will be placed roughly every 3 space modules (12 feet).



Static Framework

Due to the emphasis on modularity in the House’s design, the infrastructure was formulated around static supports framing a dynamic interior layout. Despite the fact that the movable walls, interchangeable wall and floor panels, windows, doors, and virtually every other element of the house were designed to be structurally sound while providing optimal flexibility, a need for an initial skeleton to provide core structural support was inevitable.

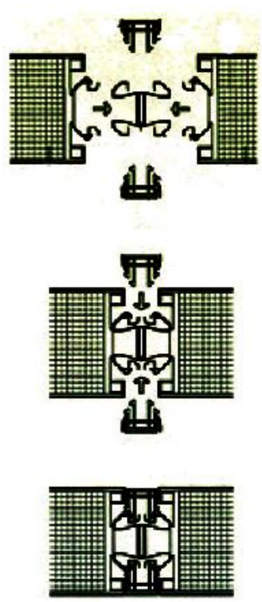
This skeleton will be the first item assembled on the site and will act as a framework around which the rest of the house will be assembled. The framework will consist of beams and supports made out of various materials. The materials will be dependant on multiple factors such as house size, number of stories, and future expansion.

Panelized\Wall Snap System

The Integrated Snap-Lock Wall System, which consists of an interconnection of multiple kinds of line-assembled prefabricated panels, is a crucial solution for a feasible modular design. The system's panels could be specifically designed to form a structural envelope that eliminates the need for conventional framing and provides integral acoustic and thermal insulation. In addition, because the panels' assembly does not require specialized laborers, installation of walls is easy and inexpensive.

Interlocking Wall Panel

Panels could be made out of a variety of easily maintained components. New panels could be added or removed to modify the changing needs of the occupants. The Panels' snap-lock connections could be easily released which ensure that building components remain in excellent condition even after disassembly guaranteeing their possible reuse or resale.



Roofing

The roof of the House will be made of materials that are durable, reusable and energy efficient. Metal and polymers will be used for their light weight, insulating and reflective properties, and ease with which they can be reused or recycled. Other roofing systems could be used based on the owners taste or extra needs. Energy producing roof systems such as the solar roof panels and solar shingles can be used if the owner so wishes.

Energy Systems

Many different types of systems were researched to determine a system which would allow for maximum sustainability and flexibility while remaining cost-effective to the user. These systems include solar, wind, geothermal, hydrogen, and traditional power grid energy sources.

Solar

Since a house or a building is considered the point of consumption, the best way to harness solar energy is to use PV (photovoltaic) cells and maintain readily-available energy. A photovoltaic cell is a solar-energy-absorbing device based on the photoelectric effect. PV cells transform part of the energy of photons into electrical energy.

By using photovoltaic cells, roughly 100 watts per square yard of solar cell are generated using current PV panels[1]. With current technological advances modules can be built into glass skylights and walls. The design could use integrated PVs that are environmentally responsive and aesthetically pleasing. In addition, building-integrated PVs provide dual-use of building materials and reduce PV systems cost.

Wind

Wind turbines convert part of the kinetic energy present in the wind into electrical energy. They can be built together with PV panels, where the panels are incorporated onto the turbines or as stand alone devices. A degree of sustainability can be attained with wind turbines doubling as PV panels.

When built separately, wind turbines provide independence from infrastructural services and at the same time their overall impact on the environment is minimal compared to other methods of energy production such as use of fossil fuels. This alternative method of producing energy, however, has the same downsides as a photovoltaic system.

During its life cycle, a wind turbine affects the environment in different ways. Production processes and the preparation of materials have a negative effect on the environment, and the wind turbine may present both visual and noise-related problems. In contrast, the generation of energy by the turbines and the high level of recycling produce a positive impact. Wind turbines also operate differently compared to PV panels. The life cycle of a wind turbine is generally shorter than that of a solar panel and its cost-effectiveness depends greatly on its continued use.

[1] Independent article. "Energy efficiency and renewable energy". http://www.eere.energy.gov/ retrieved 04/2006

Grid Power

Static power distribution grids are infrastructural power distribution systems. They are the cheapest ways to produce and distribute energy. By utilizing a local power grid, the cost per kWh of energy is reduced considerably. This option is the cheapest of all power supply systems to be setup, since it requires the least initial investment.

Water Systems

Resource-efficient plumbing consists of different devices that can be integrated into the water/plumbing system in order to minimize water utilization and provide easy installation and maintenance. The system integrates a plumbing manifold, low-flow and low-flush fixtures, air admittance valves, a tankless water heater, and grey water management.

Plumbing

The plumbing system integrates the plumbing manifold, low-flow and low-flush fixtures and air admittance valves. The plumbing manifold is a centralized water distribution system which consists of several valves that provide installation of a water line without the need to shut off the entire system. It has built-in quick connectors which further simplify the installation of water lines.

Air Admittance Valve

Comment [ES1]: This is copied from http://www.toolbase.org/techinv/techDetails.aspx?technologyID=140
Please paraphrase this paragraph and reference it.

Air admittance valves (AAVs) are pressure-activated, one-way mechanical vents, used in a plumbing system to eliminate the need for conventional pipe venting and roof penetrations. A discharge of wastewater causes the AAV to open, releasing the vacuum and allowing air to enter plumbing vent pipe for proper drainage. Otherwise, the valve remains closed, preventing the escape of sewer gas and maintaining the trap seal. Using AAVs can significantly reduce the amount of venting materials needed in a plumbing system, increase plumbing labor efficiency, allow greater flexibility in the layout of plumbing fixtures, and reduce long-term maintenance problems associated with conventional vent stack roofing penetrations.

Water Heating

Water heating is achieved by the use of a tankless water heater. The tankless water heater is a heat exchange chamber in which water makes multiple passes around electrical heating elements. The heating elements only work when there is a demand for hot water therefore eliminating the constant use of energy. This system therefore conserves energy by ensuring energy is only used when it is needed.

Grey Water

Comment [ES2]: Reference the source: http://www.nemmar.com/real-estate-Greywater-Reuse.html

Grey water, or wastewater from sinks, washing machines, and dishwashers, can be treated and reused. A grey water system generally consists of a three-way diverter valve, a holding tank, a bilge pump, a treatment assembly such as a sand filter, a disinfecting or leaching system and the re-use storage tank.

The holding tank cools the water and temporarily holds it while the bilge pump pumps the water at a selected rate to the treatment assembly. The water is treated and sent to the leaching system where it is disinfected and ready for reuse. Finally all treated and disinfected water is stored in the re-use storage tank.

Heating and Ventilation

HVAC System

The Decentralized Heating Ventilation and Air Conditioning (HVAC) System consists of multiple exchanging units distributed throughout the entire building, usually one per zone and a main chilling and boiling unit which is located outside the building.

Due to the need of a system which is able to adapt to allow for individual space load changes, the decentralized HVAC system seemed like the best choice for the house. The system works by moving energy around in water form rather than in form of air. The pipes required to move water for the same load are much smaller than the ones needed for air. The system allows for a zone division of the ventilated space since each zone or house section will be handled by a dedicated unit allowing one section to be in heating while another is in cooling. Since the units are zone specific, malfunctions or shutdown of equipment of a certain zone or section of the house will affect that only that section.

While a decentralized unit provides compatibility with a modular design, the system has some downsides which include maintaining equipment spread throughout the building and within occupied spaces. In addition, equipment life of the decentralized system is slightly shorter than the centralized system.

In addition, in order to decrease energy consumption, there is a need to automate the different system in the house specially the Heating Ventilation and Air Conditioning system. Through the use of the Programmable Logic Controllers (PLC's) motion, and temperature sensors as well as a well design logic which takes into account time of the day, humidity among others, the optimal operating point can be calculated. Therefore, comfort is maximized. In addition, when there are no occupants in the house the equipment operating point can be reduced. That is the load could be changed so that the equipment lowers its energy consumption among others.

Ceiling-Concealed Fan Coil

Fan coil units allow for intake and outtake of air. The ceiling concealed fan coil system works with the decentralized ventilation system of the house to ensure efficient flow of air. The external chilling and boiling unit send out energy in form of water which is easily moved to the ceiling through flexible piping to the fan coil unit. Within the fan coil unit, the energy is then converted back to air which is then released into the house section where the unit is installed.

Construction

Site Issues

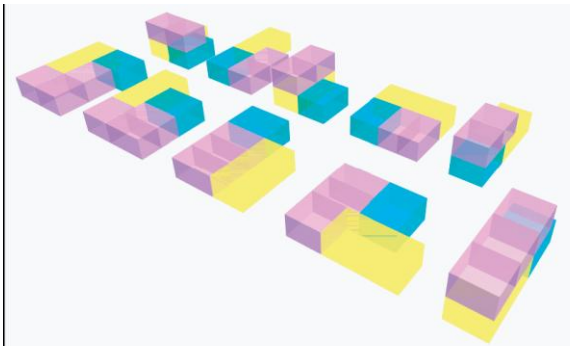
In relation to the House of the Future, the site and its location is designed and chosen with flexibility and durability in mind. The intended home should be designed to adapt to any location and situation that is within the context. The site and the establishment of a building depend on size, cost, and the environmental impact. The site constraints which will restrict construction on specific land parcels are environmentally preserved areas, brown fields, and areas not permitted by the state or local government. Besides these constraints, the House of the Future is intended to be adaptable to areas which will both benefit home and environment.

The house should consciously be built with sustainability and renewability as the main focus. Designing in this way will significantly boost the relationship between the environment and the home. The size of the site will depend on the size of the home. It is unreasonable to build a 2 to 3 story building on a high density space for a family of 4. It is more logical for a high density site to have a smaller and compact building so that the cost of construction is not significantly high, but the price of location will be extreme, such as city lots. On the other side, low density spaces, such as those found in most American suburbs, have no or little limitations to land size.

Comment [ES3]: Explain the concept that the generally the location is a key issue to determine the size of the house which strictly depends on construction cost and land value. See if you can relate the sustainability and renewability concepts to the site issue more directly.

Site location is not a major issue for this project since the home itself is meant to be adaptable in any situation and location. In order to figure out if a modular home is permitted on a specific site, it is advisable to check local and national codes and limitations. The house is specifically designed to accommodate any code constraints put on the site.

Site Design
Due to its inherent modular design the structure can fit a multitude of patterns to conform to the site's or user's specification.



Materials

A major factor in the building of the house is the acquisition, production, and assembly of the materials. Due to the intentions of the concept for the house to be prefabricated in a controlled environment, intended to be mass produced, and produced in a modular units, the materials acquisition and production has a wide range of features and possibilities.

The initial acquisition of materials will be implemented wherever in the world the specific material need is most abundant, cost efficient, and most conductive to a healthy environment. For instance if bamboo flooring is required for a specific module, it would then be shipped from South East Asia where renewable sources of bamboo are readily available. Centers would be located all over the world that would work in conjunction to provide low cost materials at an extremely minimal effect to the surrounding environments.

After acquisition, materials would be shipped to controlled environments to be prefabricated. In factories prefabrication would ensure limited waste of materials and fast construction of sections and parts for the house. Additionally, quality control could ensure that each part of the house was flawless and up to predetermined standards before it even arrived at the site.

All sections produced would be *modular units* that could interchange any other modular unit of the same type. This allows for sections of the house to be mass produced, while at the same time making it possible for preexisting modular homes to recycle and replace given sections of their house.

Modular units also aid in increasing the flexibility of the structure. Each modular unit can have a customizable aesthetic appearance, which could change depending on the taste of the user. For instance an external module could have the appearance of brick while another could portray typical aluminum or plastic siding; both of which would be just as easy to produce and ship.

Transport

Since the housing concepts are intended to address flexibility to a number of sites and cultural situations, a system of transportation is needed to address availability and delivery of modules and materials to a particular location. With the material modules sized at 4’ x 4’ and the structure at 12’ x 12’, these modular sizes allow all items to be easily shipped in a standard flatbed truck. In effect, the modular units cut costs and do not require additional costly permits typical of wide load shipments.

It is envisioned that a network of production facilities and warehouses will be created and assigned to produce materials for a specific location. Each facility is bounded to produce for an area 500 miles in radius to its location. This is the maximum transport range a truck will travel at an affordable cost, roughly one days worth of driving.

Housing sections can either be prebuilt and shipped to a site to simply be put in place, or components could be shipped, built on-site, and then put in place. With the use of standard flatbed and semi trucks either option is both affordable and easily implemented.

Assembly

Major advantages of the proposed modular system are the reduced construction time and manpower. Since the components of the future building are prefabricated and then shipped to the site, the term “assembly time” more accurately describes the process on the actual site.

According to the U.S. Census Bureau[2], construction times for residential buildings vary from an average of 5.9 months for homes built for sale to 9.8 months for owner-built homes. These numbers indicate that when the future inhabitants pay for the finished product, construction times are kept to a minimum to increase the profit margin for the builder, whereas in owner-built construction, where the consumer directly pays for the labor costs, labor tends to be a lengthier process.

The modular building system provides consumers with the option to assemble their own home. Unlike in traditional construction, there are no waiting periods involved (i.e. setting of concrete for foundation). Assembly can take place at any time of the year. Parts are small and light enough to be handled without the use of heavy machinery. Detailed instructions are supplied with the building materials and the assembly process does not require skilled labor. Depending on the size of the individual project (and thus the preferences of the client) the future inhabitants will be able to assemble the house by themselves within days (for small, simple projects or emergency housing) or weeks (for larger projects where immediate availability is not a requirement). Since the assembly process is a standardized one, manufacturers could potentially offer an optional on-site-assembly service with pricing based on number and kinds of parts for clients who opt to not build their own home.

The proposed modular system streamlines the process from planning to occupation of a new home and makes it more transparent for the average consumer who does not posess expert knowledge of construction. Since the majority of the construction costs are rolled into the manufacturing costs the overall costs are easy to calculate for the consumer. The standardized assembly process reduces construction time on site to a minimum, while the option to self-assemble eliminates the added expense of manpower.

[2] http://www.census.gov/const/www/lengthoftimeindex.html

Health and Safety

Many of the ideas and concepts put forth in this project have not yet been widely utilized in the housing industry; therefore, a need to inspect the safety considerations that the project would impose on the structure, occupants, and community was required. Safety considerations were inlayed within every concept as well as any product that would be put into the facility.

Along with the safety and health concerns, the house was designed to meet as many sustainability and green awards as possible. The objective of this was to both help the inherent design of the facility, as well as to ensure the house could meet environmental demands on a global level.

Structural Safety

One of the key factors of the house was the structure itself. The structure has to be stable and secure and able to meet many international standards in order to stand up to conditions imposed anywhere in the world. There were both short term and more stable long term considerations that were taken into account when designing how the concepts would add to the sustainability while keeping the house structurally safe.

Short Term

Short term structural safety will be achieved by using the interlocking modular panel system. The panel system is made to be easily put together. Once put together the panel walls will remain structurally sound until the owner chooses to detach the system. The system will allow the walls to be changed, replaced, or moved around; after which the full structural safety will return to its maximum possible when all the panel walls are in place.

Long Term

Long term structural safety will be achieved by using sustainable and adequately strong materials. The four-by-four-foot module that is being used may be combined into larger twelve-by-twelve-foot modules. These larger structural modules will be built with very strong materials such as steel or carbon fiber beams to ensure long lasting durability and as much structural support as is needed. These structural elements were chosen for their ability to be sustainable as well as able to support the live and dead loads of the entire house, internal element, and inhabitants.

Occupant Health

A major concern for the House of the Future is the safety and health of the occupants. Some concerns are waste control, adequate ventilation, fire safety, carbon monoxide detection, etc.

Fire Safety
To protect the occupants against fire hazards, the House of the Future was designed to comply with National Fire Protection Association (NFPA) guidelines (see appendix). Most of the materials used will be fire proof or fire resistant.

Waste Control
Waste control will implement a gray water system to cut down on waste produced in the House of the Future. The system must ensure that mixing of the grey water with the potable water is nonexistent. In addition the waste system's vent pipes will be unneeded with the implementation of a vent less system.

Ventilation
The HVAC system must conform to the international code for mechanical systems (IMC). The system used in the House of the Future will meet or exceed these guidelines and keep the air quality and temperature safe for all occupants. The ventilation must also ensure the detection of carbon monoxide, radon, or other toxic gases.

Natural Disasters
Depending on the location of construction the House of the Future may need protection against natural disasters such as floods, earthquakes, tornadoes, etc. These threats must be assessed on a case-by-case basis. Based on what threats exist and the magnitude of each, different systems will need to be implemented.

Home Security
The need to keep outside threats from entering the House of the Future also exists. This will be accomplished primarily by using stronger materials to keep the threats from gaining access to the inside of the dwelling. Future considerations may include more advanced systems for additional deterrent measures.

Community Health

Effects on Society

The House of the Future project focuses on the effects on society. The project shall have more beneficial effects on society than detrimental effects. These consist of ideas such as renewable energy, accessibility, on-site power generation, etc.

Renewable energy is derived from any source that can be maintained in a constant supply over time, such as wind power, solar electric, solar hot water, or biomass.

Accessibility ensures the availability of accessible residential housing that is safe, functional and desirable for generations of Chicagoans with disabilities. The House of the Future project should exceed accessibility code requirements for residential units. Requirements may vary according to the type of modular house.

On-site power generation of electricity simultaneously provides extremely efficient power and reduced demand on our electrical infrastructure. The House of the Future should provide power generation that is sized for a minimum 50% of building peak load.

Transit oriented development (TOD) focuses a mix of land uses, such as residential, office, shopping, civic uses and entertainment within easy walking distance from a transit station (1/4 mile, 510 minutes) to form vibrant neighborhoods. Difficult-to-develop areas have historically experienced a low amount of new residential development. The project should be located in specified census tracts, near public transit and with minimal parking.

Because of the continuing advancement of green building technologies, plans may include innovative strategies for consideration that provide energy efficiency and environmental benefits.

Natural ventilation relies on the wind to keep a building cool. The wind will ventilate a home or business by entering or leaving windows or other building openings. The House aims to provide a natural or hybrid ventilation system serving 50% of the regularly occupied areas.

Effects on Local Habitat

To maintain the highest standards for health, safety, and welfare, the following recommendations are required to eliminate the code barriers identified:

- Clarify allowable landscaping and site development approaches to improve storm water management and natural hydrology and reduce water consumption.
- Modernize requirements for emergency lighting to reduce energy consumption.
- Adopt national standards for use of fire-rated electrical equipment and wiring above ceilings or below floors to encourage use of modern, efficient HVAC systems and electrical fixtures.
- Adopt national ventilation standards to reduce energy consumption and improve indoor air quality.
- Adopt standards for determining required number of plumbing fixture to reduce materials and space associated with excess fixtures.
- Allow modern technologies and create new standards for plumbing systems that minimize water consumption.

Awards

Current Standards

Since there was no example for modular type housing, the code applicable to the modular house is same as current standards. However, it is recommended to set up inspections for various models of modular houses, as the dynamic nature of the internal layout may pose hazards not yet considered in traditional architecture.
The variations are identified by removing these code barriers.

- Life Safety Code: Means of Egress
- Electrical Code
- Mechanical Code
- Plumbing Code
- Existing Buildings
- Interior Environment Code
- Mechanical Code
- Plumbing Code
- Regulations Outside of Building Code

Future Standards

It is encouraged that building design, construction and renovation in a manner that provides healthier environments, reduces operating costs and conserves energy and resources. When building green, it is recommended to adopt a holistic building design approach that treats architectural and engineering systems as a single element of interdependent parts, recognizing synergies and tradeoffs between design decisions.

Conclusion

There have always been advances in architecture and housing construction. However, by reshaping the fundamental system by which houses are constructed, advances can be made much faster and with far greater and more immediate tangible results. Houses can be built based on a modular infrastructure, yielding lower production costs following initial investments, increased production capacity, ease of construction, adaptability to a wide range of environments through the use of advanced foundation systems, and the ability to scale to a range of dimensions to fit into a range of urban, suburban, or rural zoning and planning schemas. Through the use of next-generation technologies in heating and cooling, power, plumbing, and even the arrangement of the interior walls, the occupants of the House of the Future will be afforded a flexible, comfortable, and dynamic habitat which is not only accommodating to its inhabitants, but is accommodating as an inhabitant of its natural surroundings as well.

Future Work

Now that a system for construction has been developed, further steps can be taken to bring the House of the Future from concept to reality. As technology progresses, new techniques, products, and materials will become available. These can be integrated into the design to meet the demands of an ever-changing climate and ever-growing populations. Advances in energy efficiency, material reuse, and safety precautions can be implemented and concepts reworked to offer “greener” habitats that coexist less disruptively with their natural surroundings, or safer and more comfortable homes for people in all regions of the world. Additionally, after a substantial initial investment for fabrication facilities and other components of a production infrastructure, costs of manufacturing and assembly will drop rapidly, permitting for rapid mass-production of House of the Future-type structures and thus next-generation houses that are not only safer, more efficient, and more flexible, but less expensive as well.

First and foremost, however, the structure must be built. Because this project has seen a methodological approach come from its efforts, the next logical step is to take that approach and craft it into a tangible product: erect the House and bring the future into today.

IPRO Challenges

There were a number of aspects of this IPRO that might have been tended to more effectively than they were. Unfortunately, these problems were not identified sufficiently early on in the course of the project, and the IPRO 301 team was left with little time in which to rectify them. What can be done, however, is the documentation and analysis of these logistical and organizational problems so that future IPRO teams may avoid them altogether or, failing such avoidance, remedy them while there is ample time remaining in the project.

Project Goal and Objective
It is vital to the success of any project that all involved members understand both the underlying concept and motivation for the project as well as the projected outcomes in terms of products, changes, or in the case of this IPRO, deliverable materials to be given to the project's administration. In the case of this project, such clarity and universal understanding was not achieved to the extent it could, and indeed should, have been. No clear goals were set, nor methods, processes, and procedures defined, at the outset of the IPRO. In the future, it would be in the best interests of any IPRO team to clarify what exactly is to be done as early as possible so that the team can then organize itself as effectively as possible to complete its defined tasks.

Dynamics of Subteams

This IPRO team was organized into three smaller subteams. The subteams acted as specialized task forces dedicated to in-depth research on the various aspects of constructing the House. Subteams were defined for researching and developing the core system of design for the House, integrating new technologies into the House to support its functions, and researching building codes, safety concerns, and human-needs considerations by which the other subteams would be guided. The problem the three subteams encountered was that of redundancy in the work addressed by each subteam. There were times during which two teams would be focusing on the same topic without knowing and without communicating to each other that such overlap had been occurring. This reinforces the need for clearly-defined goals to be established as early as is practically possible in the course of the project. Valuable time could have been reclaimed had the subteams been given clear boundaries within which to conduct their research and development.

Additionally, the IPRO 301 team divided itself into these specialized subteams too early on in the project. While it is important to establish guidelines for subteams as early as possible, this is not to say that the division itself should occur next to immediately. Had the IPRO 301 team taken more time at the outset of the project to plan overall team objectives, establishing subteam objectives and guidelines would have been made considerably less complex.

Finally, the distribution of team members into subteams was grossly uneven. The largest subteam, dedicated to developing the core system of design and construction, consisted of seven members with an overall concentration in architectural specialists. The team dedicated to researching and implementing next-generation technologies consisted of four members. The team dedicated to researching regulations, code, and health and safety concerns consisted of only two members. A redistribution of human resources would have yielded not only the benefit of more evenly distributed workloads, but also a less homogeneous design team and more representation of architectural practices and tendencies in those subteams whose focus was not primarily architectural in nature.

Communication

Communications between subteams, as well as team and subteam leadership, was key for this IPRO as it is to any IPRO now or in the future. While the IPRO 301 team had little to no difficulty in the realm of administrative concerns such as these, it bears mentioning that future IPROs should strive to implement strong leadership and frequent and fluid communications. With solid communication of expectations, plans, progress, and requirements, each member of the IPRO team will be able to work more efficiently with less strain put on them to deliver despite a lack of resources. This concept applies in a vertical fashion as much as it does a horizontal one: not only is communication needed within the group and across subteams, but also up to the team advisors who have a lot to offer in the way of aiding in the completion of various project tasks.

Time

With the semester being much shorter than expected, teams should establish and adhere to a timeline as quickly and closely as possible. This will allow everyone in the team to understand their expectations, while at the same time preventing team members from needing to rush to complete any project objectives.

With regard to a project timeline, contingency time for deadlines and delivery dates is paramount. By allowing for a week or more of flex time by way of creating "virtual deadlines," an IPRO team can give itself much-needed breathing room make last-minute revisions or updates to project deliverables, and to communicate concerns about those objectives or deliverables amongst its members before the time comes to submit materials to the project's administration.

Appendix A: Systems and Concepts

WeeHouse
An example of a moveable modular structure, incorporated into modular ideology for the project.

LV Kit Home
A kit home built entirely from factory manufactured pre-built building materials.

FlatPak Home
A hybrid house incorporating modular prefabricated building and on site building techniques.
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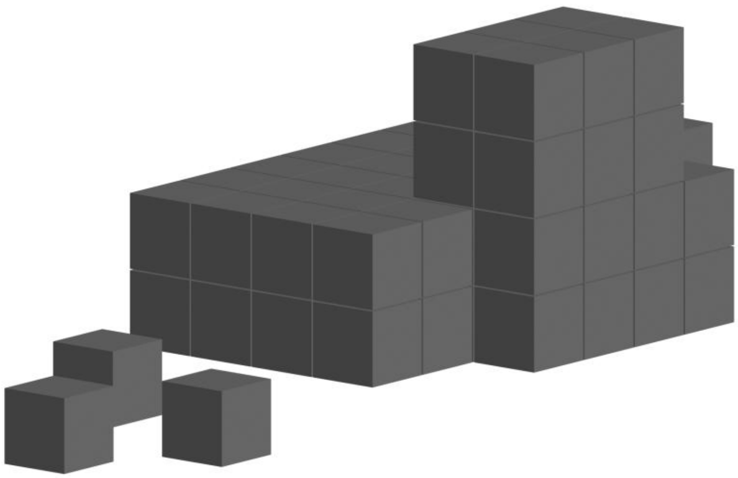
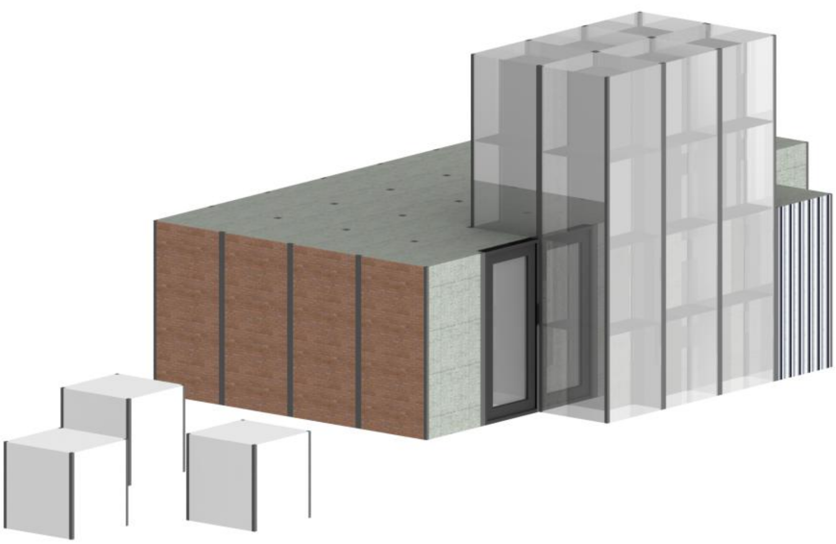
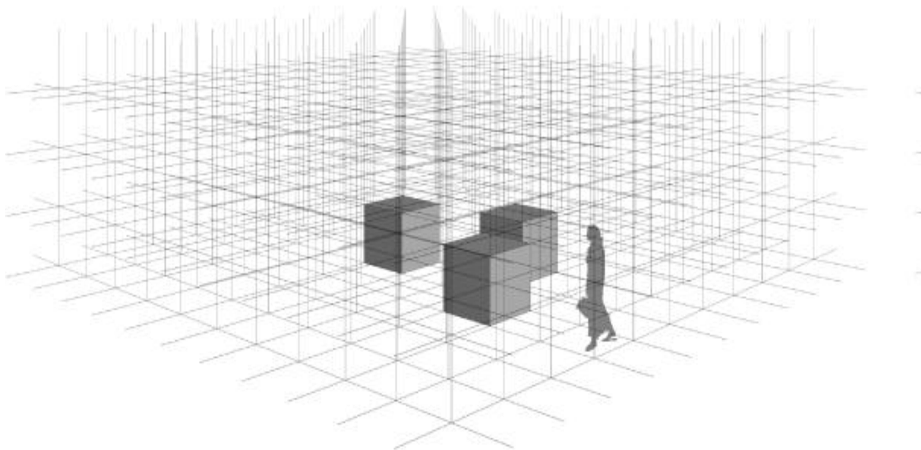
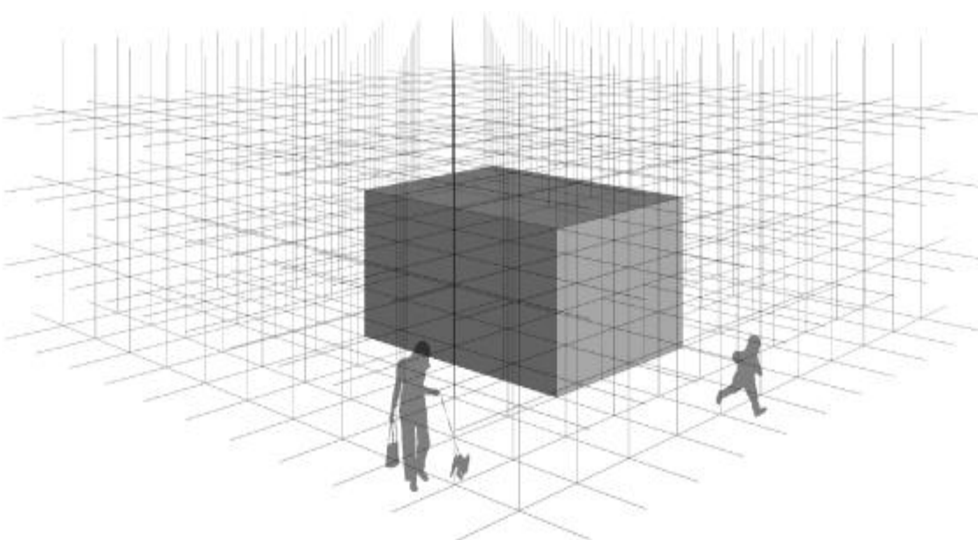


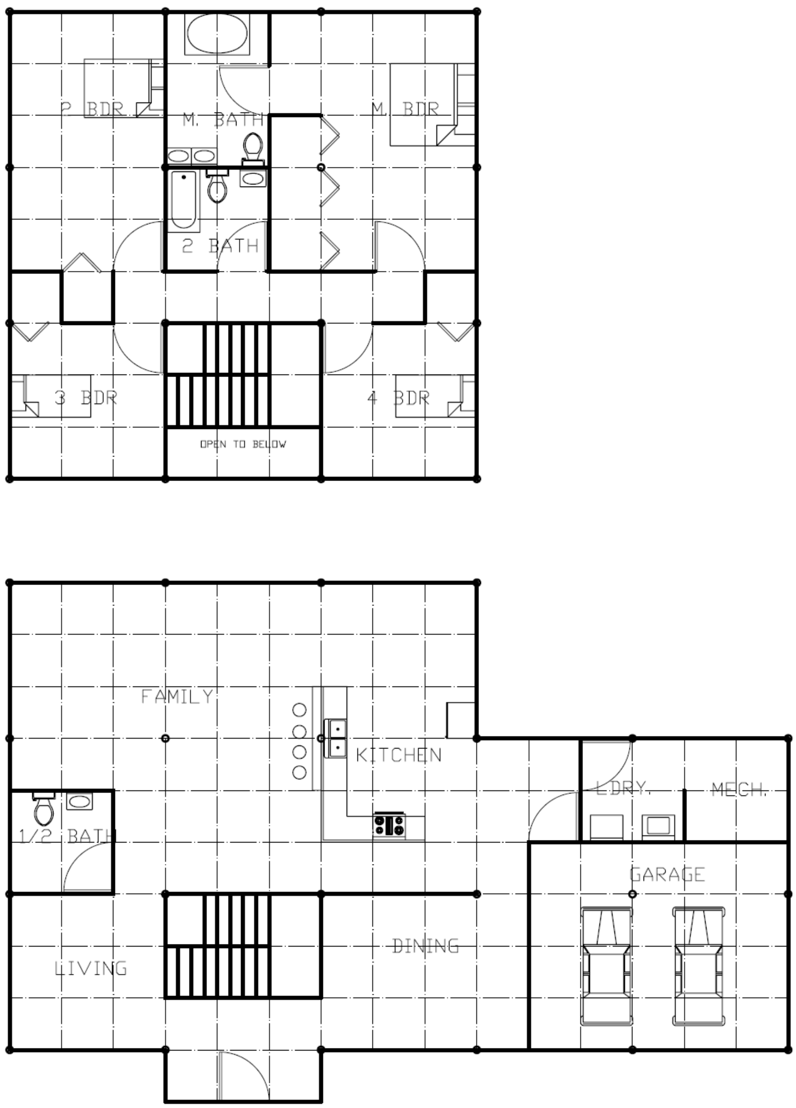


Two modular concepts developed by the IPRO 301 team to show how modularity would be incorporated within the space of house.





Two diagrams representing the spatial aspect of the modular concept.



Floor plan of a two story low density American house, includes a 2 ½ car garage, 4 bed room, 1 ½ bath.

Floor plan of a one story high density house, includes a three bedroom one bath. This would be a more typical model implanted in part of the world like India, China, and Japan.

Appendix B: Products and Technology

HVAC

Picture of a ceiling concealed fan coil[3]

THC Fan Coils—Capacity and Performance Data

Model		THCH02		THCH03		THCH04		THCH06		THCH08		THCH10		THCH12	
System		2-pipe	4-pipe	2-pipe	4-pipe	2-pipe	4-pipe	2-pipe	4-pipe	2-pipe	4-pipe	2-pipe	4-pipe	2-pipe	4-pipe
Air flow (cfm)		200		300		400		600		800		1000		1200	
ARI total cooling cap. (Btuh)		8,500		11,100		14,500		21,200		22,700		25,300		34,200	
ARI sensible clg. cap. (Btuh)		6,100		8,400		10,800		16,100		18,000		20,000		27,000	
ARI sensible hting. cap. (Btuh)		14,900	11,500	20,300	16,300	26,800	20,400	37,600	29,600	42,400	36,100	48,300	40,300	68,800	49,800
Water flow—3-row (gpm)		1.94		2.51		3.26		4.70		5.14		5.70		7.75	
Water flow—1-row (gpm)		N/A	0.64	N/A	0.91	N/A	1.12	N/A	1.65	N/A	2.00	N/A	2.24	N/A	2.76
Water PD—3-row (ft WC)		5.10		3.26		5.80		12.82		3.68		4.76		8.29	
Water PD—1-row (ft WC.		N/A	1.47	N/A	2.89	N/A	5.32	N/A	10.72	N/A	3.24	N/A	4.07	N/A	6.45
Fan(s)	Type	Centrifugal fan (forward curved galvanized steel fan wheel)													
	Number	1		1		2		2		3		3		4	
	Fan housing	Galvanized steel													
Coil	Type	Water													
	Rows*	3-row	3/1-row	3-row	3/1-row	3-row	3/1-row	3-row	3/1-row	3-row	3/1-row	3-row	3/1-row	3-row	3/1-row
	Testing press.	425 psi for 1 minute; leak test: 225 psi for 5 minutes													
Motor(s)	Type	PSC													
	Number	1		1		1		1		2		2		2	
	Power supply	115/60/1, 208-230/50-60/1, 277/60/1													
Watts—high speed	50 Hz	62		91		109		171		242		249		321	
	60 Hz	75		109		131		205		291		299		385	
Coil connection		3/4" FPT													
Drain pipe		3/4" MPT													
Ship weight (lbs.)**		61.00	63.00	69.00	73.00	83.00	88.00	97.00	102.00	127.00	134.00	137.00	143.00	146.00	153.00

Notes: Conditions: Cooling capacity: Entering air temperature 80°F (OB), 67°F (WB); Entering water temperature 45°F, Leaving Water Temperature 55°F.
Heating capacity: Entering air temperature 70°F (OB); Entering water temperature 140°F, the same amount of water flow as with cooling.
Nominal air flow: Under dry coil conditions; Fan speed high.

*3-Row = 3-row chilled water/hot water coil; 4-Row = 3-row chilled water, 1-row hot water coil.

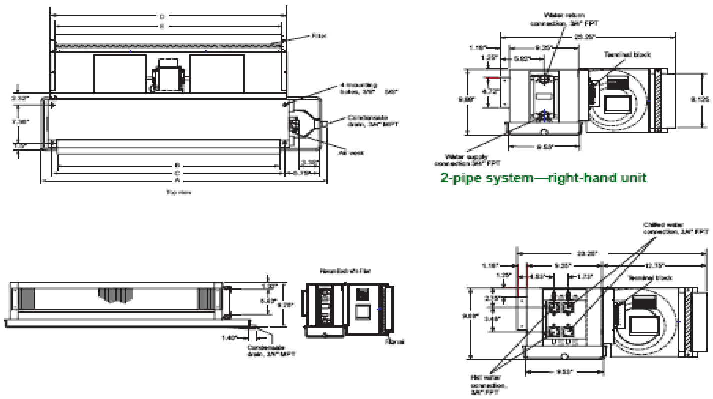
**Weight includes return air plenum and packing.

Performance Data for a Fan Coil Unit[4]

[3] 2006 Mcquay Online Catalog
http://www.go.mcquay.com/mcquaybiz/literature/lit_at_fc/PhysicalData/FCTHC.pdf (04/2006)

[4] 2006 Mcquay Online Catalog
http://www.go.mcquay.com/mcquaybiz/literature/lit_at_fc/PhysicalData/FCTHC.pdf (04/2006)

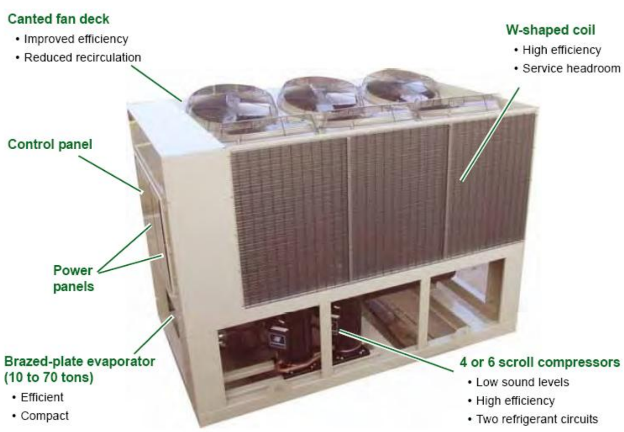
Dimensional Data



Model	A	B	C	D	E	Filters	
						Size	Qty
THCH02	32.05	17.64	19.17	19.96	18.46	18 1/8" X 8" X 1"	1
THCH03	38.74	24.33	25.87	26.65	25.15	24 7/8" X 8" X 1"	1
THCH04	43.86	29.45	30.98	31.77	30.20	29 7/8" X 8" X 1"	1
THCH06	51.73	37.32	38.86	39.65	38.07	18 7/8" X 8" X 1"	2
THCH08	61.57	47.17	48.70	49.49	47.91	23 3/4" X 8" X 1"	2
THCH10	65.51	51.10	52.64	53.43	51.85	25 3/4" X 8" X 1"	2
THCH12	75.75	61.34	62.87	63.66	62.09	30 7/8" X 8" X 1"	2

Notes: Dimensions based on unit with return air plenum and filter

Fan Coil Unit Dimensional data[5]



Chiller unit which is located outside the house structure[6]

[5] 2006 Mcquay Online Catalog
http://www.go.mcquay.com/mcquaybiz/literature/lit_at_fc/PhysicalData/FCTHC.pdf (04/2006)

Physical data	AGZ model number		
	010A	013A	017A
Basic data			
Unit capacity @ ARI conditions tons (kw)*	9.8 (34.3)	13.3 (46.6)	15.9 (55.7)
Number of refrigerant circuits	1	1	1
Unit operating charge, R-22, lb (kg)	13.8 (6.2)	14.1 (6.4)	18.0 (8.2)
Cabinet dimensions, L × W × H, in (mm)	73.6 × 46.3 × 49.0 (1869 × 1176 × 1245)	73.6 × 46.3 × 49.0 (1869 × 1176 × 1245)	73.6 × 46.3 × 49.0 (1869 × 1176 × 1245)
Unit operating weight, lb (kg)	1008 (458)	1364 (619)	1387 (630)
Unit shipping weight, lb (kg)	1075 (488)	1425 (647)	1450 (658)
Add'l weight if copper finned coils, lb (kg)	220 (99.7)	220 (99.7)	220 (99.7)
Compressors			
Type	Scroll	Scroll	Scroll
Nominal tons per compressor	6.0 / 6.0	7.5 / 7.5	9.0 / 9.0
Oil charge per compressor, oz (g)	60 (1701)	140 (3969)	140 (3969)
Capacity reduction steps—percent of compressor displacement			
Standard staging	0 – 50 – 100	0 – 50 – 100	0 – 50 – 100
Condensers—high efficiency fin and tube type with integral subcooling			
Coil face area sq ft (m^2)	30.3 (2.8)	30.3 (2.8)	30.3 (2.8)
Finned height × finned length, in (mm)	84 × 52 (2134 × 1321)	84 × 52 (2134 × 1321)	84 × 52 (2134 × 1321)
Fins per inch × rows deep	16 × 2	16 × 3	16 × 3
Pumpdown capacity lb (kg)	35.3 (16.0)	50.3 (22.8)	50.3 (22.8)
Condenser fans—direct drive propeller type			
Number of fans—fan diameter, in (mm)	2—26 (660)	2—26 (660)	2—26 (660)
Number of motors—hp (kw)	2—1.0 (0.75)	2—1.0 (0.75)	2—1.0 (0.75)
Fan and motor rpm, 60 Hz	1140	1140	1140
60 Hz total unit airflow, cfm (l/s)	13950 (6584)	12000 (5664)	12000 (5664)
Direct expansion evaporator—brazed plate-to-plate			
Connection size victaulic, in (mm)	2 (51)	2 (51)	2 (51)
Water volume, gallons (L)	.94 (3.6)	1.66 (6.3)	2.00 (7.6)
Maximum refrigerant working pressure, psig (kPa)	450 (3103)	450 (3103)	450 (3103)
Maximum water pressure, psig (kPa)	450 (3103)	450 (3103)	450 (3103)

*Nominal capacity based on 95°F ambient air temperature and 54°F/44°F water range.

Data sheet for chiller unit[7]

Note that this unit capacity is very high. Low load equipment is required and there are no line produced chillers of less than 9.8 tons of cooling capacity.

HVAC System Requirements

General requirements

1. The system must suffice the total load in a house which does not change after it has been initially calculated

[6] 2006 Mcquay Online Catalog
http://www.go.mcquay.com/mcquaybiz/literature/lit_at_fc/PhysicalData/FCTHC.pdf (04/2006)

[7] 2006 Mcquay Online Catalog
http://www.go.mcquay.com/mcquaybiz/literature/lit_at_fc/PhysicalData/FCTHC.pdf (04/2006)

2. The system must adapt to allow for individual spaces load changes since the panelized system allows for space reconfiguration, thus space function change which translates into individual spaces load changes. (zone-specific ventilation load changes)
3. The system must save space.
4. The systems must be simple so that the personnel with no training can maintain it.
5. The system must strive to save energy.

These requirements can be met with either system centralized and decentralized. In addition, with either system there is a need for automation since the load is not constant. However, more rigorous analysis might lead to a decentralized system choice based on technical problems that arise from moving air to control temperature in variable load zones in which there is not restriction as to how the load could vary. Therefore, a decentralized system offers more flexibility than a central system for a varying load.

Advantages

1. Each zone is typically handled by a dedicated unit allowing one zone to be in heating while another is in cooling.
2. Equipment malfunctions affect only one zone.
3. Scheduling can be zone-specific allowing for increased operating savings.
4. Decentralized equipment is generally straightforward to service.
5. Decentralized equipment can rival the most advanced built up systems for energy efficiency.

Disadvantages

1. Decentralized systems include maintaining equipment spread throughout the building and within occupied spaces.
2. Equipment life is generally shorter.
3. Mechanical equipment is near or inside the occupied space which creates noise and thus a problem.
4. Low load line produced equipment is not produced. The equipment has to be custom made.

Solar Energy

Advantages
1. Ideally, it provides total independence from infrastructural services
2. It is environmentally friendly

Disadvantages

1. There is a need to size every system by analyzing electrical loads.

2. There is a need to have a through knowledge of the availability, performance and cost of the components in the system.
3. Price/performance trade offs are to be analyzed and reconceived throughout the design process.
4. The system requires maintenance.
5. The storage batteries are very bulky in order to store sufficient energy.

SPECIFICATIONS

Electrical Specifications

MODEL	KC125G
Maximum Power	125 Watts
Maximum Power Voltage	17.4 Volts
Maximum Power Current	7.20 Amps
Open Circuit Voltage	21.7 Volts
Short-Circuit Current	8.00 Amps
Length	1425mm (56.1in.)
Width	652mm (25.7in.)
Depth	35.7mm (1.4in.)
Weight	12.2kg (26.8lbs.)

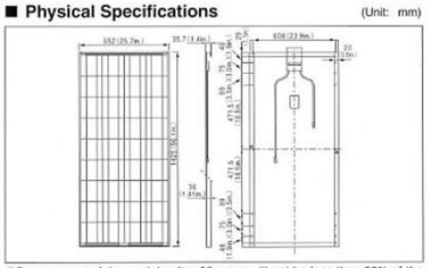
Thermal parameters

Nominal Operating Cell Temperature	47°C
Isc Current temperature coefficient (A/°C)	(8.60×10^{-3}) A/°C
Voc Voltage temperature coefficient (V/°C)	(-8.42×10^{-2}) V/°C

Note: The electrical specifications are under test conditions of Irradiance of 1kw/m^2, Spectrum of 1.5 air mass and cell temperature of 25°C

Physical Specifications

(Unit: mm)



※Power output of the module after 25 years will not be less than 80% of the minimum power specified in the data sheet.

Table of specifications for a Kyocera PV panel[8]

The PV panel shown above sells for $1220 USD. This panel has an area of about 1.1 square yards and has a power capacity of 125 W. To produce 1 kW of electrical energy, approximately 10 of these panels are required at a cost of $12,200 dollars of initial investment. Therefore, the initial investment is 12,000 dollars for every kW/h of energy produced.

Comment [ES4]: These numbers are wrong. Please who came up with these numbers need to contact me to change them.

To have and idea, if the consumption of a possible configuration of the systems proposed is about 11 kWh of energy. For this kind of load, an initial investment of $134,000 dollars is required just to supply the needs with optimal energy production. That is without taking into account that there is a need to produce almost 2.5 to 3 times that amount to store some energy to use during the night and allow for looses during storage and inversion. Therefore, the initial investment is roughly $335,500 dollars to supply the house needs of electricity using PV panels. All this analysis is made with ideal conditions.

By using software called FRESA that can be retrieved at http://www.eren.doe.gov/femp/techassist/softwaretools/softwaretools.html, which takes into account more rigorous factors such as meteorological data, performance factors among others. The initial investment goes up to $1,040,000 with an estimated return on the investment of 96 years if the panels were to be installed in Chicago, IL. The analysis does not include the cost of storage.

[8] High efficiency multicrystal photovoltaic panels. Kyocera online catalog 2006 www.kyocera.com (04/2006)

Wind Energy

A wind turbine is an energy conversion device which transforms ~~part of the~~ kinetic energy present in the wind into electrical energy.

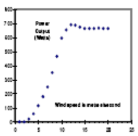
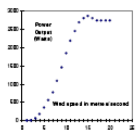
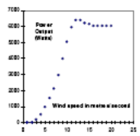
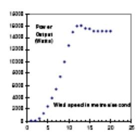
Advantages

1. Ideally, it provides total independence from infrastructural services
2. It's overall impact on the environment is minimal compared to fossil fuel energy production

Disadvantages

1. There is a need to size every system by analyzing electrical loads.
2. There is a need to have a through knowledge of the availability, performance and cost of the components in the system.
3. Price/performance trade offs are to be analyzed and reconceived throughout the design process.
4. The system requires maintenance.
5. The storage batteries are very bulky in order to store sufficient energy
6. Needs large area due to size of turbine blades

Proven Wind Turbines - Technical Specification Sheet

Rotor Speed Control Above 12m/s or 25mph) blades twist to limit power in response to high rpm ***Low Speed Equals Durability***				
Marine Build Quality All machines ***galvanised*** steel, ***stainless*** steel & ***plastic*** components				
WT MODEL	**WT600 (0.6kW)**	**WT2500 (2.5kW)**	**WT6000 (6kW)**	**WT15000 (15kW)**
Cut In (m/s)[1]	2.5			
Cut Out m/s)	None!			
Survival m/s)	65			
Rated (m/s)	12			
Rotor Type	Downwind, Self Regulating			
No. of Blades	3			
Blade Material	Polypropylene	Polypropylene	Wood/Epoxy	Glass Polypropylene
Rotor Diameter(m)	2.55	3.5	5.5	9
Generator Type	Brushless, Direct Drive, Permanent Magnet			
Battery charging	12 , 24 ***or*** 48V DC	24 ***or*** 48V DC	48V DC	48V DC
Grid connect with *Windy Boy Inverter*	230Vac 50Hz ***or*** 240 Vac 60Hz	230Vac 50Hz ***or*** 240 Vac 60Hz	230Vac 50Hz ***or*** 240 Vac 60Hz	230Vac 50Hz ***or*** 240 Vac 60Hz
Direct Heating	n/a	120Vac ***or*** 240Vac	120Vac ***or*** 240Vac	120Vac ***or*** 240Vac
Rated RPM	500	300	200	140
Annual Output[2]	900-1,500 kWh	2,500 – 5,000 kWh	6,000 – 12,000 kWh	15,000 – 30,000 kWh
Head Weight (kg)	70	190	500	1100
Mast Type	Tilt-up, tapered, self-supporting, no guy wires (Taller guyed towers also available on request)			
Hub Height (m)	5.5 ***or*** 12	6.5 ***or*** 11	9 ***or*** 15	15
WT Found (m)	1x1x1 ***or*** 1.6x1.6x1	1.6x1.6x1 ***or*** 2.5x2.5x1	2.5x2.5x1 ***or*** 3x3x1.2	3.7x3.7x1.2
Winch Found (m)	0.65x0.65x0.65	0.65x0.65x0.65 ***or*** 1x1x1	1x1x1 ***or*** 1.5x1.5x1	1.5x1.5x1.2
Tower Weight (kg)	120 ***or*** 350	241 ***or*** 445	360 ***or*** 656	1200
Mechanical Brake	No	Yes	Yes	Yes
Noise[3] **@ 5m/s**	35 dBA	40 dBA	45 dBA	48 dBA
Noise @ 20m/)	55 dBA	60 dBA	65 dBA	65 dBA
Rotor Thrust (kN)	2.5	5	10	26
Sample of UK commercial customers	British Telecom / Scottish Youth Hostel Association / British Rail / Irish Lighthouse Authority UK Lighthouse Authority / T-mobile /Orange / Saudi Aramco / Shell / B&Q / BP / Sainsbury's			

[1] 1 metre/second = 2.24 miles per hour=3.6kph.
[2] Based on an ideal site and average wind speed of 5m/s - please refere to our website at www.provenenergy.com for further information
[3] All readings taken with an ATP SL-25 dBA meter at the base of the tower at a height of 1.5m.
* A car passing 20m away @ approx 40 mph is 70-80dBA

Fuel Cells

Fuel cells might help the process of independence from infrastructural services.

A fuel cell is an electrochemical energy conversion device. It converts the chemicals hydrogen and oxygen into water, and in the process it produces electricity.

Advantages

1. Fuel cells have the potential to be up to 80-percent efficient. That is they can convert up to 80 percent of the energy content of the hydrogen into electrical energy.
2. A fuel cell generates large amounts of heat which could be utilized conventionally.
3. Fuel cells could reduce pollution to a minimum

Disadvantages

1. Hydrogen is not so readily available. There is no infrastructure in place to obtain hydrogen.
2. Hydrogen is difficult to store and distribute.
3. Hydrogen used in a fuel cell must be pure to get the desired efficiency coefficients.

General Electric Company commercializes a fuel cell, which is produced by Plug Power® that uses a natural gas or propane reformer and produces up to 7 kW-h. A system like this produces electricity and significant amounts of heat, so it is possible that the system could heat a house and provide all the available energy. The downside to using this type of fuel cell is that, the reformer is used to get the hydrogen from your gas utility line (from hydrocarbons) producing other gases besides hydrogen. This decreases the cell efficiency as well as it does not solve the problem of pollution.

It is important to note, that due to the cost of producing and storing hydrogen this choice of system should be for extremes cases in which the other alternatives can compare to it such as in cases where there is no other source available.

PRODUCT CHARACTERISTICS		5B48	5U120
Performance	Rated Net Output[1]	0 to 5,000 W	0 to 5,000 W
	Adjustable Voltage	46 to 56 Vdc (48)	125.9 to +136.2 Vdc (120)
	Operating Voltage Range	42 to 60 Vdc	125.9 to +139.8 Vdc
	Operating Current Range (net)	0 to 109 Amps	0 to 39.9 Amps
Fuel	Gaseous Hydrogen	99.95% Dry	99.95% Dry
	Supply Pressure	80 +/- 16 psig (5.5 +/- 1.1 bar)	80 +/- 16 psig (5.5 +/- 1.1 bar)
	Fuel Consumption	40 standard liters per minute at 3,000W	40 standard liters per minute at 3,000W
		75 standard liters per minute at 5,000W	75 standard liters per minute at 5,000W
Operation	Ambient Temperature	-40°C to 46°C	-40°C to 46°C
	Relative Humidity	0% to 95% Non condensing	0% to 95% Non condensing
	Altitude	-197 ft to 6000 ft (-60 m to 1829 m)	-197 ft to 6000 ft (-60 m to 1829 m)
Physical[2]	Dimensions	44"H x 26" W x 24" D (112 cm x 66 cm x 61 cm)	44"H x 26" W x 24" D (112 cm x 66 cm x 61 cm)
	Weight	500 Lbs (227 kg)	500 Lbs (227 kg)
Safety	Certification	FCC Class A	FCC Class A
Emissions	Water	Maximum 1.75 Liters per hour	Maximum 1.75 Liters per hour
	CO, CO2, NOx, SO2	<1ppm	<1ppm
	Audible Noise	60 dBA @ 1m	60 dBA @ 1m
Sensors[3]	Gas Hazard Detection	Included	Included
Control	Microprocessor	Included	Included
	2 LED Panel	Included	Included
	Low Fuel Alarm	Included	Included
	Communications[4]	RS-232C	RS-232C
		Digital Form C Contacts	Digital Form C Contacts

[1] Output rated from -40°C to 42°C. From 42°C to 46°C, output decreases 2.5% per degree Celsius. Above 1000 feet (305 meters), an additional de-rating of 1.5% per 305 meters applies.
[2] Excludes fuel storage.
[3] Optional sensors are available to detect Pad shear, water intrusion and tampering.

This table provides information on Gencore® available fuel cell model with natural gas reformers[9].

An important fact that must be considered is that one of the models consumes 40 liters of hydrogen per minute for every 3 kW of energy produced. For an estimated average of 11kW-h of energy needed which is about 183 watts per minute, there is a need to spend about 2.4 liters of hydrogen per minute at atmospheric pressure. The cost for every kilogram of reformed hydrogen is about 11 dollars (Production cost) not to mention the price for the natural gas that was reformed[10]. The density of hydrogen is 0.09 gm/cubic meter which is 0.09 kg/liter. Therefore, the cost of producing the needed hydrogen is $2.2 dollars a minute. All these calculation are not rigorous and are intended to give an idea of the cost.

[9] Plug Power online catalog 2006 http://www.plugpower.com/products/pdf/GENCORE_UPS.pdf (04/2006)
[10] Margaret K Man. Independent article. www.nrel.gov (04/2006)

Tankless Water Heater

Model 165 Technical Specifications	
Dimensions:	13.5" x 16" x 3"
Weight:	12 lbs.
Materials:	Copper Exchanger / Aluminum Casing
Pipe Fittings:	3/4" Standard Pipe / ASTM B-88
Voltage:	208-240 volts/single phase
Max. Amps:	68.5 AMPS at 240v
Breakers Required:	1 x 70AMP breaker
KW / Elements:	14 - 16 KW / 4 elements
Energy Efficiency:	99.5%
Activation Flow Rate:	0.25 gpm
Frequency:	50/60 Hz
Operating Range:	5-150 psi
Protection:	Thermal / Manual Reset
Warranty:	Lifetime 100% Parts Replacement
Certifications:	UL and ULC Listed

Maximum Output Temperature Chart				
Flow Rate GPM	45° Inlet Temp.	55° Inlet Temp.	65° Inlet Temp.	Max. Temp Rise @ 240V - °F
0.5	140	140	140	108
1.0	140	140	140	108
1.5	123	130	140	75
1.75	112	119	129	64
2.0	104	111	121	56

Advantages

1. Energy saving.
    a. Savings results from elimination of standby losses from warmed water sitting in a tank.
2. Installation
    a. Ease of installation. They are often installed under sinks, in closets or in other locations where they can be accessed.

Manifold plumbing system

Manifold plumbing systems are control centers for hot and cold water that feed flexible PEX supply lines to individual fixtures.Separate manifolds can serve hot and cold water lines. The cold water manifold is fed from the main water supply line and the hot water manifold is fed from the water heater. Water pressure in manifolds is maintained by the incoming service line.

Appendix C: Code and Safety

DCAP Green Permit Program Green Menu Items

Green Roof
Green roofs or rooftop gardens reduce storm water runoff, help reduce the urban heat island effect, improve air quality and conserve energy.
Provide a vegetated rooftop system for a portion of the roof built in accordance with standards for planned developments.

Renewable Energy
Renewable energy is derived from any source that can be maintained in a constant supply over time, such as wind power, solar electric, solar hot water,
or biomass.
Provide 1% of the total annual energy use from onsite renewable energy sources.

Extra Affordability
The City of Chicago is committed to strengthening neighborhoods and enhance affordability by providing a range of housing opportunities for Chicagoans.
Provide 30% of residential units qualifying as affordable housing per Chicago Department of Housing standards.

Accessibility
The City of Chicago Building Code ensures the availability of accessible residential housing that is safe, functional and desirable for generations of Chicagoans with disabilities.
Exceed accessibility code requirements for residential units. Requirements may vary according to the scale of the project.

On-Site Power Generation
Generation of electricity and heat simultaneously provides extremely efficient power and reduced demand on our electrical infrastructure.
Provide a combination of heat and power generation that is sized for a minimum 50% of building peak load.

Transit-Oriented Development and Difficult to Develop Areas
Transit Oriented Development (TOD) focuses a mix of land-uses, such as residential, office, shopping, civic uses and entertainment within easy walking distance from a transit station (1/4 mile, 5-10 minutes) to form vibrant neighborhoods.
Difficult to Develop Areas have historically experienced a low amount of new residential development.
Locate the project in specified census tracts, near public transit and with minimal parking.

Innovation
Because of the continuing advancement of green building technology, plans may include innovative strategies for consideration that provide energy efficiency and environmental benefits.

Exceptional Water Management
Water efficiency is one way of addressing water quality and quantity goals. The efficient use of water can also prevent pollution by reducing wastewater flows, recycling industrial process water, reclaiming wastewater, and using less energy.
Stormwater management is the process of controlling and processing runoff so it does not harm the environment or human health.
Meet LEED requirements for both water efficiency and stormwater management.

Exceeds LEED or EnergyStar Certification
Achieve a higher certification level than required by the Green Permit Program.

Natural Ventilation
Natural ventilation relies on the wind to keep a building cool. The wind will naturally ventilate your home or business by entering or leaving windows or other building openings.
Provide a natural or hybrid ventilation system serving 50% of the regularly occupied areas.

References and Resources

Prefabrication Resources

http://design.walkerart.org/prefab
Title: Walker Art Center
This site is a special exhibition on prefabricated housing, with a nice overview on the field of prefabricated housing. It contains links to several "prefab" house designs.

http://www.metropolismag.com/cda/story.php?artid=1693
Title: Pliny Fisk III
This article describes sustainable options for prefabricated housing.

http://re4a.com/modern-modular/
Title: Resolution: 4 Architecture
This company has several diagram layouts for modular housing on their site.

http://www.fabprefab.com/fabfiles/fablisthome.htm
Title: Fab List
This page has an extensive list of current prefabricated housing on the market as well as proposals, includes links to websites of architect and or vendor or supplier

Following books were a good overview of the ideas concerning prefabrication and prefab construction.

PreFab
by Alejandro Bahamon
Publisher HBI (Feb 2003)
ISBN: 0060513586

PREFAB
by Bryan Burkhart, Allison Arieff
Publisher: Gibbs Smith (Sept 2002)
ISBN: 1586851322

Building Envelope Resources

http://www.houseofthefuture.com.au/hof_houses06.html
Title: Houses of the Future
This covers different types of houses that are made of Glass, Concrete, Clay and the Cardboard House. The site also covers design concepts that include nanotechnology, the latest in glass technology, environmental features and Historical/theoretical precedents.

http://www.sampe.org
Title: Society for the Advancement of Material and Process Engineering
This site has information about material and process engineering technology by which materials are developed or selected and the manufacturing processes chosen to convert those materials into products that meet the design, performance, quality, and cost effective criteria required.

http://www.helicalpiersystems.com/res-apps/res-new.htm
Title: Helical Pier Systems
This group promotes screw piles in building systems. Screw piles have the capability to handle various loadings and are ideal for building on weakened soil sites, high-capacity foundation applications, new construction foundations, fast efficient construction and cost-effective foundations.

http://robotcombat.com/store_carbon_fiber_samp.html
Title: Composite materials-carbon fiber
This site allows purchase of graphite-reinforced plastic or carbon fiber reinforced plastic (cfrp or crp) samples. CFRP/CRP is a strong, lightweight composite material, the next generation of building materials.

http://www.spec-net.com.au/company/gjames.htm
Title: G. James
G.James is an Australian Integrated Glass and Aluminum Manufacturer and Contractor, their site provided information on use of glass and aluminum in building structures.

http://www.Isotruss.com/technology.asp
Title: IsoTruss
The IsoTruss patented technology offers structural technologies that are lighter, stronger and more efficient than traditional materials.

Inner Building System Resources

http://www.c2c-home.org/compete.htm
Title: C2C Competition Winners
The C2C Home Competition received more than 625 design submissions. The second place professional winner, Patrick Freet designed the snap lock wall system.

http://www.nahbrc.org/docs/NewHomeButtons/ConferencesandSeminars/4837_PATHplumbing.pdf
Title: PATH: A Resource Efficient Plumbing Overview
This document lists advantages of resource efficient plumbing. This system is energy efficient and easy to construct.

http://www.toolbase.org/techinv/techset1.aspx
Title: Tech Set 1
This page highlights five technologies that are easy to install, including tankless water heaters, plumbing manifolds, and low flow fixtures. They result in efficient and speedy delivery of hot and cold water, and allow for future retrofitting of a greywater reuse system.

Alternative Energy System Resources

http://www.absak.com/diagram/general/index.html
Title: ABS Alaskan company
This website provides the "basic home power system diagram" which shows basic components for any alternative energy system, wind, water, or sun. Further the website has information about limitations of renewable energy and recommendations for the Alaskan climate, namely a combination of wind, water, sun and traditional generators.

http://www.oksolar.com/roof/
Title: Oksolar
This is one company offering photo voltaic roofing shingles. This page explains specifications and design as well as installation and warranty, along with pictures and reasons to buy.

http://www.hgtvpro.com/hpro/bp_mechanical/article/0,2617,HPRO_20151_4243877,00.html
Title: HGTV
A network for home and garden information, it champions solar shingles as "attractive, environmentally friendly way for reducing energy costs" They introduce the benefits of the system to a wide audience, and educate consumers about site and use considerations.

http://www.alpinesurvival.com/system2.htm
Title: Alpinesurvival
This website has a variety of survival type articles, this one in particular offers photographic diagrams for solar powered systems and reminds U.S. consumers of the federal tax benefits for installing now.

http://www.utilityfree.com/wind/remotesys7.5.html
Title: Utilityfree
This company sells various renewable energy systems. Their site offers several diagrams of wind and solar powered systems. They display specifications for hybrid or stand-alone systems, components and general information about placement.

http://www.backwoodssolar.com/interests/sellpower.htm
Title: Backwoods solar
This small company's site offers information about solar power for small systems and remote areas. They mainly promote reducing consumption and using the most energy efficient appliances as a way to use solar for all your power needs.

Code and Safety Resources

http://www.madcad.com.ezproxy.gl.iit.edu/madcad/index.php
Title: MAD-CAD
MAD-CAD is a site that contains an extensive list of up to date building codes including International Codes, BOCA codes, Standard Building Codes, Uniform Building Code, NFPA Standards, CABO/ANSI.

http://www.ci.chi.il.us/dcap
Title: City of Chicago Department of Construction and Permits
The City of Chicago Department of Construction and Permits (DCAP) is a newly formed department dedicated solely to encourage development and renovation in the city through the issuance of construction permits.

http://www.wbdg.org/
Title: World Building Design Guide
The WBDG is the only web-based portal providing government and industry practitioners with one-stop access to up-to-date information on a wide range of building-related guidance, criteria and technology from a 'whole buildings' perspective. Currently organized into two major categories—Design Guidance and Project Management—at the heart of the WBDG are Resource Pages, reductive summaries on particular topics.

http://www.escapeconsult.com/index.shtml
Title: Fire Escape Systems
This site has information about evacuation of high rise buildings during fires. Especially important in the case of "building up."

http://www.newtopiamagazine.net/archives/content/issue17/features/greencity.php
Title: "Green City, Chicago"
This article shows several codes and issues for making a green system of an existing building.