ENERGY PROGRAM

Alison McLellan
Architectural Programming, ARCH 449
Professor Jean von Bargen

Introduction

In response to worldwide social and environmental crises, I will design a model for contemporary living in the extreme context of Guangzhou, China.

As China rises in today's economy, it has the opportunity to use the authoritarian government and financial power to demonstrate sustainable solutions to the growing population and improved standards of living around the world. Government leaders have shown a desire to develop their economy using "green" principles, and are responsive to new ideas about environmental stewardship. However, in the rush to become a world player, China has left behind tradition- often at the cost of its complex and deeply rooted society. A gap has appeared between the young, business-oriented, and western generation and the older, traditional generation. Since the rise of Chinese society several thousand years ago, all generations of extended family form a "jia," a term for which there is no direct translation. A jia is a family unit, in which all members live and work together, supporting each other throughout their lives. The jia has begun to disappear, a surprising feat of capitalism that even communism failed to complete, despite great efforts to do so.

This project aims to demonstrate that not only can China develop on a sustainable path, but also family and community ties are a part of sustainable living, not a cost. The development, sited in the most modern district of Guangzhou, will include living for a range of income levels over commercial space and markets. Most important, however, is the public space between the apartments and shops. Outdoor living has always been critical to Chinese culture, both in private and public spaces. The development will provide all the needs of the jia; it will also be a carbon-neutral and off-grid development treating all waste on-site using strategies replicable around the world.

Energy Consumption

A critical element of this project is demonstrating the possibility of living well without large power plants supplying dirty and non-renewable energy. The social aspects are nearly impossible to measure or quantify, but the environmental aspects can be easily understood. Not only must the development provide 100 percent of its own power, the strategies used to reduce power use and produce the necessary electricity must be clear and replicable. The Chinese have no qualms about copying an idea; in this case, I will exploit that to the fullest and make the strategies obvious and attractive to developers. The only constraint is the poor quality control and

material quality available in China; while the government will likely jump on the opportunity to add a product or process to their economy, it will fail if dependent on extreme precision or high-quality materials.

Energy Conservation Strategies

The climate in Guangzhou is semi-tropical, with intense cooling needs for most of the year and no heating needs. While the temperatures are not extreme, high humidity levels exacerbate high temperatures. Because there are a high number of sunny days (and a large separation from surrounding tall buildings), reasonably steady wind, and a very high density of residents to produce waste, the following strategies should provide all energy needs.

Building Design:
- Incorporate shading on south face to reduce cooling load
- Orient building to avoid east, and west exposure
- Orient units to take advantage of northern light for daylighting
- Provide for passive ventilation with open plans and operable openings to the north and south (aid ventilation with fans)

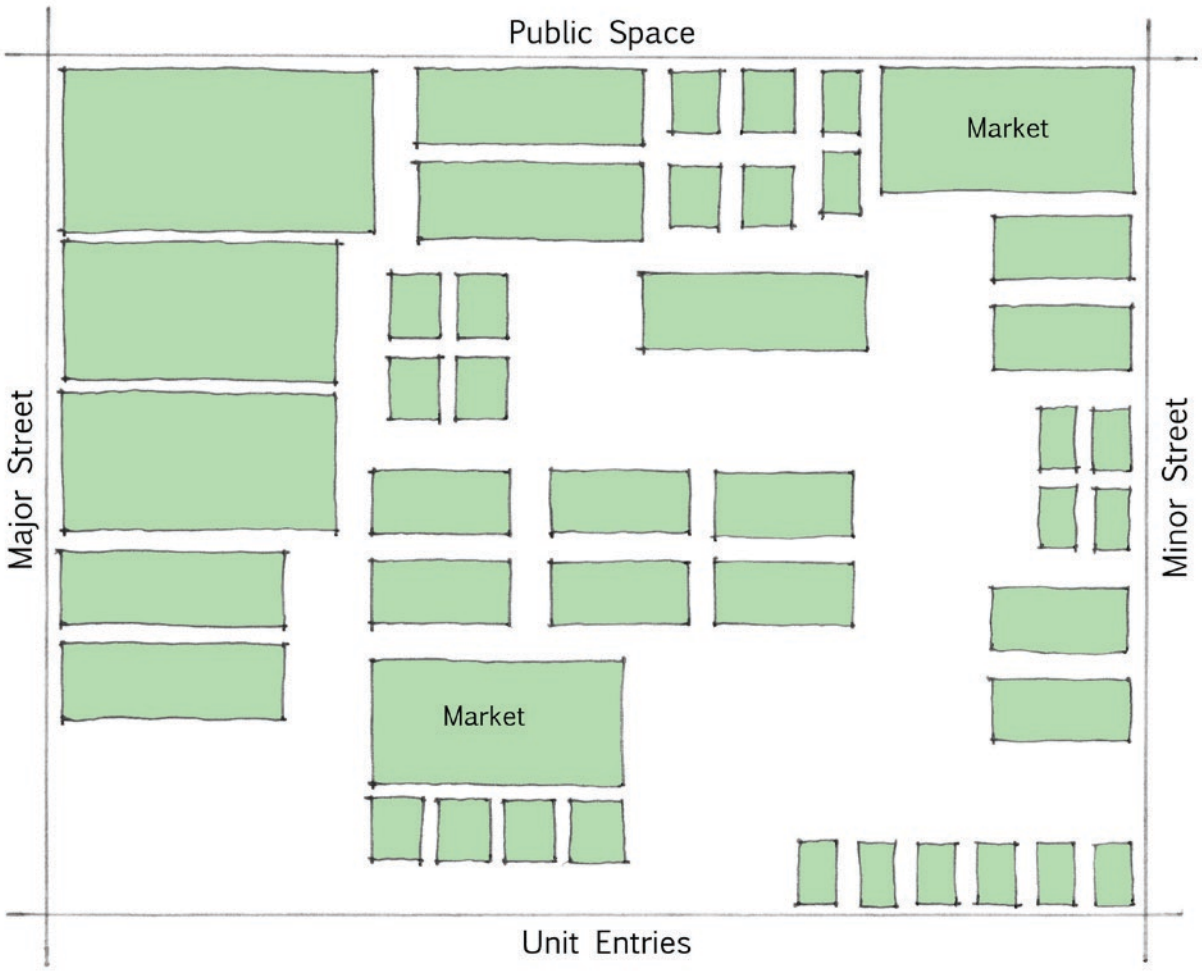
Solar Power:
- Use photovoltaic arrays as shading on south elevation
- Step building up to north side of site to allow maximum exposure to PV array
- Curve building back to allow optimal degree of exposure
- Include solar water heater at each level as needed by units

Wind Power:
- Include turbines in building design
- Use building features to direct wind to turbines

Waste Recovery:
- Process waste for energy production with anaerobic digester, incinerator, or other system as necessary. This method is the last resort for energy production.

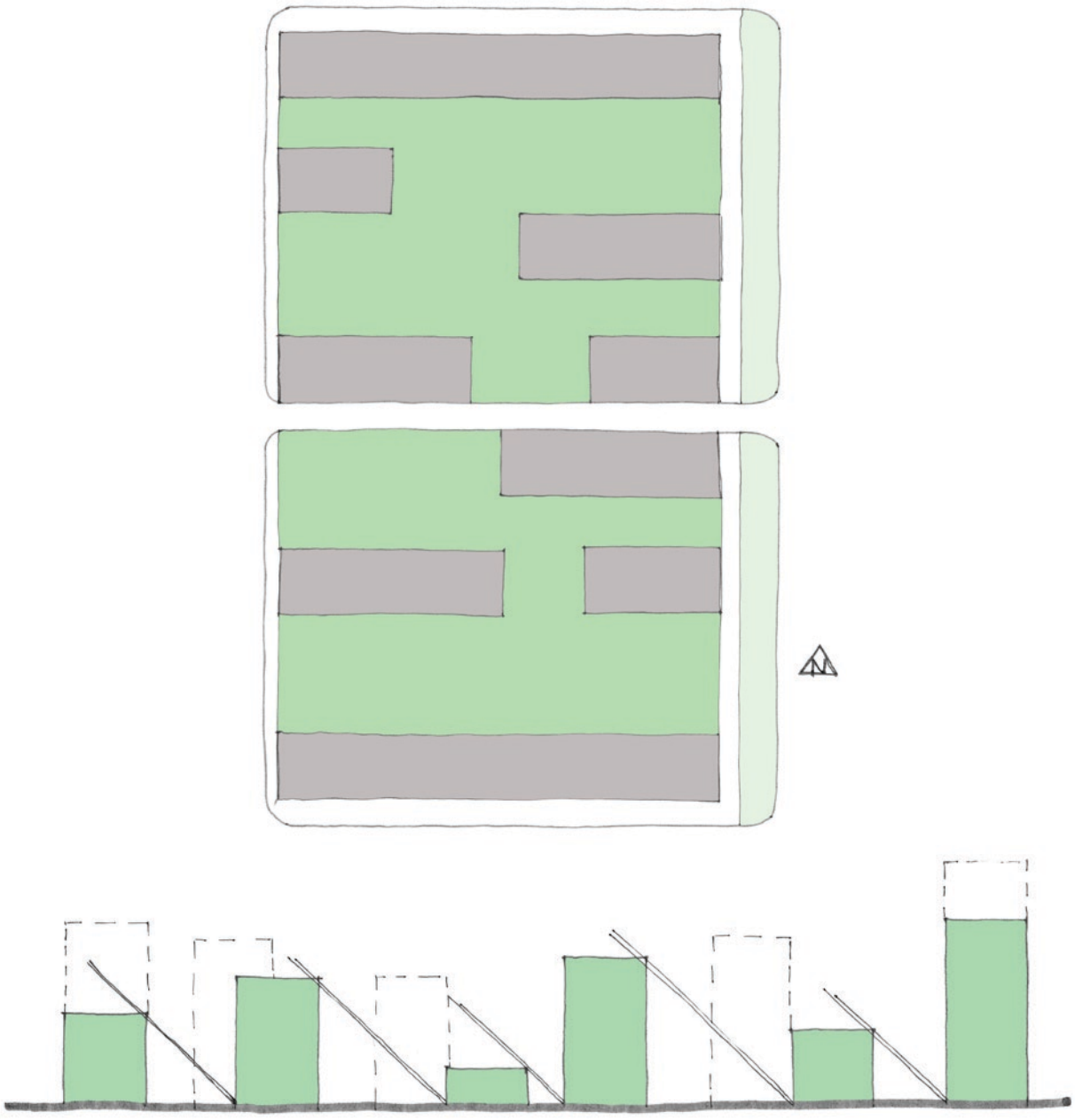
Energy Groups

The commercial spaces do not present a wide array of energy needs- most of the spaces are small and open. All of these spaces will be open during the day and evening, will require cooling (mainly from shading and ventilation) and most likely will not produce excessive energy. The spaces will be left loosely planned and minimally finished to allow a high degree of customization, again lowering predictable deviations from standard commercial energy needs. Most important is the location in relation to public spaces and streets, as illustrated in the diagram below.

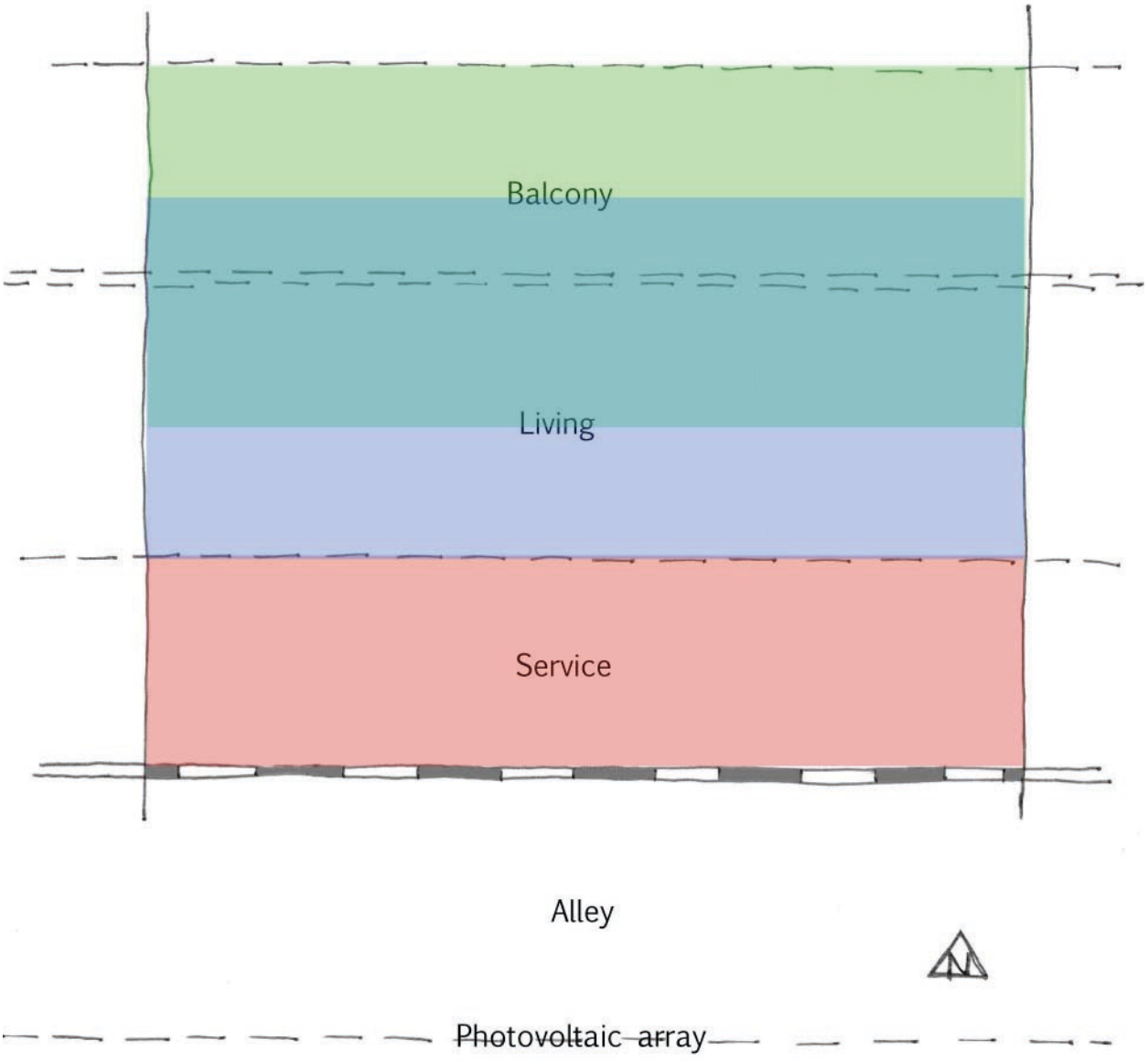


The markets present requirements different from the other commercial spaces; they are open air, but covered. It is likely that daytime cooling will be moderated by nighttime ventilation of mass; this is possible because the markets are on the ground floor, where the concrete structure will be exposed to provide the mass, and because the space will be completely open to breezes during the night. Other commercial spaces will need more active cooling methods.

Above the commercial space are residential units, from two to four bedrooms, and a dormitory. Again, the energy needs are uniform within this type. The diagrammatic plan and section below indicate the orientation of the buildings on the site to take advantage of northern light for daylighting and avoid east and west exposure. Staggering the buildings allows a higher density while permitting sun to reach the outdoor spaces and the south faces of other buildings (for solar collection). The section shows the sun angle at noon on the winter solstice. The commercial buildings may extend beyond the footprint of the residential towers, providing another level of green space and allowing clerestories for daylighting in the commercial spaces.



The southern face will be shaded with a photovoltaic array; the units will be accessed from an open walkway behind the array. This evokes the traditional alleys of China and provides a thermal buffer zone. Only transom windows high on the wall will open onto this alley, assuring privacy and limiting solar gain. On the north side, the line between inside and outside is vague to assure ventilation and optimize daylighting. The unit is no more than 30 feet deep including the balcony; no portion of the unit will be out of reach of daylight (aided by the transom windows for the kitchen and bath). The unit diagram below indicates the arrangement of a unit that responds to cultural norms and traditions while addressing energy needs.



Red: kitchen, bath, closets. Moderate light needs. Task lighting in kitchen.
Blue: living, high light needs. low task lighting.

	Activities	Occupants	Num.	Area per (sf)
2 Bedroom apartments	Living, sleeping, cooking	Parents with no or one child	80	700-800
3 bedroom apartments	Living, sleeping, cooking	Parents with one or two children, possibly	200	800-1000
4 bedroom apartments	Living, sleeping, cooking	Parents with one or two children, possibly	80	1000-1200
Migrant worker dorms				
single room	sleeping, living	one tenant	15	180
double room	sleeping, living	two tenants	35	220
Shared living	living	Up to 50; usually 15-30 at one time		2500
shared kitchen	cooking	up to ten; usually 1-4 at one time	5	300
Mid-size commercial	shopping or offices	employees and shoppers	3	5000-8,000
Small commercial	shopping or offices	employees and shoppers	40	400-3000
Markets	shopping	vendors and shoppers	2	6000
Community Center	games, group events	small groups, periodically large groups of 50+	1	2000
Public bathrooms	toilets and handwashing	one attendant, 3-6 people at one time	3	400

	Height (ft)	Lighting	most active time	Temperature
2 Bedroom apartments	9	moderate ambient light,low task light	evening and morning	Summer cooling
3 bedroom apartments	9	moderate ambient light,low task light	evening and morning	Summer cooling
4 bedroom apartments	9	moderate ambient light,low task light	evening and morning	Summer cooling
Migrant worker dorms				
single room	8	low ambient light, high task light	evening and morning	Summer cooling
double room	8	low ambient light, high task light	evening and morning	Summer cooling
Shared living	10	high ambient light,low task light	evening and morning	Summer cooling
shared kitchen	10	moderate ambient light, high task light	evening and morning	Summer cooling
Mid-size commercial	12+	high ambient light	daytime	Summer cooling
Small commercial	10	high ambient light	daytime	Summer cooling
Markets	12	high ambient light	daytime	Summer cooling
Community Center	10	moderate ambient light, low task light	daytime and evenings	Summer cooling
Public bathrooms	9	moderate ambient light	daytime	none

Conclusion

The energy needs are consistent across most of the ground floor and for the residential spaces above; this aligns neatly with the uses and divisions of public and private space, bringing together the goals of ecological living and social sustainability. Maintaining the alignment of the social and environmental needs will lead the design process. I will also discover, as the design progresses, which energy sources can be used for each need and how much wind and waste power must be produced. Daylighting studies will determine the most ideal layout and blend of indoor-outdoor space to balance lighting with ventilation and potential heat gain. The integration of all the sustainable principles into the design of the building, such as the use of the photovoltaic array for shading of an outdoor corridor, will assure that these strategies cannot be left out of an imitation design.