Balancing Urban Housing with Infrastructure Systems:
De-Carbonizing Urban Communities for 2050

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Introduction

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The Players 2008-2010

> 4 professors: architects, urban design/planning and landscape architect
> 6 architects and engineers from Sekisui House, Japan (at MIT)
> approximately 43 students in total from:

> architecture professional program (MArch)
> architecture post-professional program (SMArchS)
> building technology
> city planning
> landscape architecture
> media lab

Introduction
Context + early sustainability systems ideas
Shinjuku
23.7km (14.7mile)
25min to the center of Tokyo
Tama Context

Tama New Town

Tama New Town 1970

Tama before development (partial view)

Tama master plan model (partial view)
Train bound for center of Tokyo

48.6ha
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Restructuring Tama NT
Towards Zero Negative Environmental Impact
The problem of Japan and feasibility of Tama

Understanding the environmental, social and demographic context of the urban community that defines ‘sustainability’
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Vision for Flexible Adaptable Tama:
Small multi-generational, mixed use, university town with connection to Tokyo, responsible for providing the majority of consumed energy and processing the majority of its waste, with desirable living spaces, and built in flexibility to adapt as time.

Original vision for Tama
1960s housing, with proximity to Tokyo
Mirror supportive retail / industry

New vision for Tama
Updated housing, with proximity to Tokyo
University as major industry, retail satellite

Principles:
1. CARBON ZER0: All buildings can only nomination producing energy sources
2. FLEXIBLE BUILDINGS: Sustainable and other buildings should follow a basic outline that can be modified and used for housing or other purposes
3. CONCENTRATED SERVICES: Retail should be concentrated along connective lines, corridors rather than squares
4. MULTIPLE USES IMPLEMENTED
5. EDUCATION AND TRANSPARENCY: Education and transparency of operations should be a top priority in all developments
6. EFFICIENT AND EFFORT-SAVING: Efficient and effective services should be provided to all residents
7. WASTE REDUCTION AND COMPOSTING: Waste reduction should be more local, every year

Scenarios for designing: FLEXIBILITY AND ADAPATABILITY OVER TIME
Current energy flows

Proposed energy flows

Energy flows

Transit Strategy

The last mile transit problem

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Team Two: Building Resiliency
Chris Guignon, Haruka Haruchi, Deborah Morris, Sarah Snider

Team Two: Building Resiliency

Community resilience: beyond a single use mono-culture
A denser, consolidated community where agriculture / food, transportation and ecological restoration strategies are reinforced.
Team Three: Women in 2050

Growth scenario:
1. current facilities
2. creating public space hubs
3. housing neighborhoods
4. encouraging alternative growth
5. boundaries and directed growth to prevent sprawl

Employment demographics

Demographics:
2010
2020
2030
2040
2050

Lifestyle:
This regional map of the Tokyo Metropolitan area shows the disconnection of natural and urbanized areas. This map illustrates the potential for creating more natural connections in the future. This movement of water through natural landscapes can enhance important connections between residential and hydrological systems.

Tama New Town in the regional eco-context: Scenario for addressing habitat fragmentation through landscape ecology.

**Tama Context**
Ecologic Oriented Development (EOD):
A Pattern Book for Site Planning

Site & Infrastructure Planning Studio > Spring 2009
Massachusetts Institute of Technology
School of Architecture + Planning

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Ecologically oriented development studio
Site Transformation
Time Series

Native Landscape pre-1940s
Site Engineering and Construction 1970s
New Town Development 1970s - Present
Sustainable Housing and Community Future Design

Topography transformation

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OPTIONS FOR PHYSICAL REUSE
a) Keep as is, reuse for ad-hoc community needs
b) Strip down to structure, build new "facia"
c) Keep existing facade, gut + renovate interior
d) Add new + integrate with existing structure
e) Retain existing foundations, build new above
f) Demolish building and reuse materials elsewhere

Tama Context

Urban Renaissance Agency (URA) demonstrates retrofit project (Source: URA, Japan)
Tier One Principles:

1. 100% energy production on site
   energy self sufficiency / zero energy importation

2. development of zero-emission mobility system
   all electric systems within site/ on demand access integrated with other low energy solutions

3. 100% grey water reuse
   all storm and housing grey water to be re-used/ no net import of water.

4. adaptable community housing units
   housing units to be adaptive to change over lifetime and reconfigurable (long life loose fit)

5. 80% reduction on 1990 levels of carbon by 2050
   progressive reduction of total site carbon profile/ carbon footprint per person

6. 50% of available open space used to support local community based agriculture and industry
   supports local community based employment initiatives

7. 60% reduction in energy use
   (compared to existing codes) use of passive heating and cooling climate strategies, conservation and behavioral change

Tier Two Principles:

8. use of ecological construction systems

9. conservation of habitat and landscape continuity

10. green economics: sustaining the local economic base

11. deployment of digital information systems

12. reconfigurable architectural systems for housing

Research timeline + guiding principles
Carbon metrics
Carbon reduction: metrics
Carbon reduction: metrics
Mobility Projections

Current
- METRO
  - Source: Electric Power

2050
- METRO
  - Source: Renewable Energy

AUTOMOBILE
- Source: Electric Power

BUS
- Source: Solar Electric

Energy Source Over Time
- Chart showing changes from gasoline to solar electric and wind as well as shared automotive use from personal to shared.

Carbon reduction: mobility

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Diagrams of Carbon Reduction Over Time

Carbon reduction: mobility

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**Carbon reduction: energy**

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60% reduction in household energy consumption by 2050

Solar Power in Tama:

Today: 0%
2010: 70%
2030: 95%
2050: 111%

Diagram of Carbon Reduction Over Time

Carbon reduction: energy

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According to the Japan Steel Can Recycling Association, 88.1% of steel cans were recycled in 2006.
Carbon reduction: green space
Carbon reduction: green space

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Carbon reduction: water

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Carbon reduction: water

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Site development

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Planning Concepts

The following diagrams illustrate four different but coordinated concepts that will shape the transformation of the Newtown site towards a new community for 2050 and the next 40 years of its existence. The chapters for housing prototypes and infrastructures then go on to elaborate on how these concepts get fleshed out in terms of urban housing design at different densities and serve as physical strategies for the site and its topography.

Site development

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Mobility Infrastructures

The integrated mobility network is a system of overlapping scales and modes of transportation. From walking and biking trails to personal rapid transit and commuter trains, the new town offers variety and accommodation to residents. With an overlapping network, one can ride a bike to the bus stop, park it at a local transfer station, and take the bus to work. Another resident may take his car directly from his home and park it at a community covered lot, where it will charge until he is ready to leave. Yet another resident may simply need a parking spot or a quick charge in the middle of an errand. This instantaneous charge is also available at individual charging posts. The proposed charging and transportation systems are indeed redundant to accommodate the various needs of users and lifestyles. Examples shown here are simply a few of the proposed types of transit hubs and park-and-ride systems proposed in the new development.

Site development
Vehicle Sharing Network

CityCar (GPS enabled)

CityCar Station B (Rack & Kiosk)

Scooter Station A (Rack & Kiosk)

Network Link

Network Link

Network Link

Network Link

Mobility-on-Demand Network management engine

Computer

PDA/Cell Phone

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2) A lateral rather than linear approach to how people use the street
3) Integration of ecological and digital infrastructure to reduce environmental impacts.
Street design
The Public Sphere: Ecological Productive Landscape

Street design

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The S-House

Tama New Town is a classic example of problem areas in Japan where housing was built to suit lifestyles of a younger generation. Currently, the population of Tama is scarcely half of the projected capacity and the aging population is finding the existing housing types ill-suited. While the current problem areas are mid-rise, one system propose here is a smart, efficient, and adaptable low-rise private house that can accommodate the changing population: the S-House. The S-House is designed to optimize solar collection, cross ventilation, and flexible planning for the changing Japanese population. Each unit shares the common feature of a circulation and ventilation core. This two meter wide spine is oriented south for optimal solar collection and angled to enable for vertical circulation through stairs and serve as a ventilation core. In addition, this compact core nests storage or electric vehicle parking underneath the circulation, compressing site usage to a minimum. The new home is designed to maximize natural lighting throughout the day while energy collected during the day can power interior lighting at night. With optimal solar collection and ventilation, the core is the perfect location for the living machine which brings the new, sustainable performance of the development into the forefront of the home.

The S-House is deployed through simple expansions of the core. The open plan allows for maximum flexibility and transformation over time. With the core as the circulation center, the house expands easily in either lateral direction for larger living spaces or to frame private courtyards. To demonstrate the flexibility of the S-House, we take six scenarios of Japanese families, ranging from a single occupant to a multi-generation home.

Housing prototypes: low density

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Housing prototypes: low density

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Housing prototypes: low density
Housing prototypes: low density

The L-House

The L-shaped house is a concept that enables 4 houses to share a courtyard or common landscaped space in multiple ways to make an urban residential unit that maintains the individuality of the house but also creates a shared urban space. The shared spaces of the public domain in and around the housing can be used for gardens or be a part of a concept for community spaces and local agricultural production. The house itself is highly adaptable to different sizes, plans, and configurations for families. It could be scaled smaller than the plans indicate if an overall reduced plan size is required.

The plan is based upon a modular concept of 3 square units which are linked or connected through courtyards and stairs. The modular idea enables rooms to be interchanged - an office workspace can be incorporated instead of an additional bedroom or a 3rd or even 4th bedroom can be exchanged for a studio office. The plan also offers the possibility for a Japanese room to be located adjacent to a small enclosed courtyard.
**Housing prototypes: low density**

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Housing prototypes: low density
Plan options with different sized lots and courtyards:
A second floor can also be added in different configurations to create variety

Alternate organizational systems enable streets to be oriented differently with differing densities

Housing prototypes: low density
Housing prototypes: low density

Typical plan of courtyard houses, roads, shared landscaping and shared 'productive' landscapes.

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Housing prototypes: low density
Connected Courtyard

Housing prototypes: medium density
Housing prototypes: medium density
The Urban Villa

This medium density scheme draws its inspiration from the western townhouse typology. The neighborhood is comprised of a series of streets off of which the building entrance is located. The back face is orientated toward nature and/or productive landscapes. Each building is designed to be an individual entity with shared energy collection and passive cooling systems. Together these buildings create a traditional urban fabric.

The buildings are organized to provide a hierarchy of public spaces. The largest scale of public space is achieved with grand avenues that act urban centers capable of supporting commercial programs. The perpendicular streets linked to the main cores are the main access routes to the residential buildings. And finally, smaller alleys off of the streets create secondary connections to green spaces and local car-sharing networks.

The Villa is an exercise in passive and active climate and energy production systems within a familiar building typology. Via operable windows each of the through units can be naturally ventilated. A vertical stack at the center of the building further encourages non-mechanical ventilation at the middle and most dense zones of the unit.

A shade screen not only defines the buildings outdoor privately-shared space but it also guards the southern facade from unwanted heat gain. Additionally, it establishes a light and flexible infrastructure for photovoltaic panels if needed due to excess demand. The terraced roof is shaded by the same system and accommodates a permanent infrastructure on the roof for concentrated solar collectors.

Housing prototypes: medium density

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Housing prototypes: medium density

Unit plan options to show flexibility in organizing the villas for different family sizes and needs.
Housing prototypes: medium density

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The Loft-Block

The Loft-Block is a new typology for medium density housing that integrates walk-up linear apartments that run through the width of the block, with elevator access mini tower housing onto the street. Collectively it forms a series of south-facing wedge-like buildings, each of which can vary in width, taper and length as the through units get stretched. Each pair of buildings is then raised off the street so that the undercroft is used to house supporting programs - shops, industry, offices, education - and the elevated landscape garden is used to retain or control water run-off and to be a private garden that meshes with the city landscaping. At the roof level, the units break out into a series of roof top terraces with a layered grid again providing solar shading and an armature for solar energy production using parabolic collectors. Windows to the south and west facing elevations are recessed from the wall to provide shading against excessive solar heat gains and the simple planning of the linear through units enables effective natural cross-ventilation.

Housing prototypes: medium density

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Housing prototypes: medium density

Diagram to show the paired relationship between lift-blocks and lower-level houses. Courtyards calibrate within the rooftops.

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Housing prototypes: medium density

Key diagram to show how the plan configurations for each block can accommodate different unit and family types. See diagram on left for plans correlating to each color band.
Housing prototypes: medium density
The Linear Block

The 'Linear' Block strategy is to develop a community of south-facing, thin linear buildings that connect to a lower element that frames onto the street and house mixed use programs. The layout creates a courtyard for each linear block to be used for productive community farming or agricultural plots managed by the community of the building. Each block could have a system of shade screens to the south façade and roof landscapes and could also be used for a green/vegetative façade system.

The Stepped Block

The Stepped Block is an arrangement of 2-7 storey buildings which can be oriented both to the south and to the east. Between each of the units, the community shares a system of plots, gardens, and green spaces. Each block has a series of roof gardens and terraced tanks at the roof level, while the long south-facing façade has a series of through-apartments enabling cross ventilation and shading by overhanging balconies.

The Atrium Block

The Atrium Block is a concept where two blocks that face each other share a glazed and shaded PV and power generating atrium space which is used for accessing the condensate, and is a shared semi-indoor microclimate garden and thermal buffer. Each clustered pair of blocks is organized such that they avoid being too close to another cluster. Blocks would be planned linearly such that they create a series of strips for the site plan, enables the negotiating of topographical changes, and create a differentiation between types of public or communal landscapes.

Housing prototypes: higher density
In order to achieve a self-sufficient and sustainable high-rise housing typology, special consideration must be paid to the energy technologies that power the multi-story blocks as well as the efficiency of individual units to achieve a lower net-demand. Simply coating the roof of the building will not provide enough power to satisfy the demand, but through a combined approach of energy conservation and site specificity, each block can achieve relative self-sufficiency. The buildings take advantage of orientation to harvest prevailing wind energy through the corridors between adjacent blocks as well as incident solar energy that falls on the expansive south-facing slope. Individual housing units are designed as double-height "duplex" apartments, each of which has abundant through ventilation to the opposite side. By alternating the circulation corridors on one side of the building, each apartment is given access to views through the block from east to west. This also takes advantage of wind-driven ventilation to minimize the use of artificial cooling during the warm months.

The site for these Tapered Blocks contains alternating agricultural and recreation corridors. The circulation side, containing the elevator and stair cores for each building, empty out onto a shared recreation space composed of shaded tree farms and tennis courts. The opposite side of each block faces out onto a central agricultural strip that takes advantage of harvested rainwater to irrigate and maintain small-scale co-op farming. Wind turbines are located in the center of this agricultural corridor as it is oriented towards the primary southern wind direction. Every apartment is given access to a balcony or roof deck to promote healthy outdoor interaction, while the deluxe units containing roof decks are also given private green houses that overlook each terrace.

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Housing prototypes: higher density
Housing prototypes: higher density
Housing prototypes: higher density
Ecological Footprint

The ecological footprint is a metric for relating the human demand for resources to the capacity of the earth and the ability of its ecosystems to supply or generate that demand. Measured in 'global hectares per person' (gha), it acts as an indicator to compare the consumption of one country, region, or community to another, but also as a metric to evaluate the means to reduce our over-dependence on the earth’s eco-systems. The following diagrams are intended to bring awareness to this issue within the context of Japan and Tokyo, and more specifically to the dilemma between attempting to move toward self-sufficiency versus increasing density as a possible site for a more sustainable community.

Japan’s Ecological Footprint:
4.3 gha/person

Japan’s Domestic Supply:
0.8 gha/person

Japan’s Ecological Debt (Imported):
3.6 gha/person

Global = 1.2; China = 1.5; Japan = 4.2; US = 9.1

Eco-footprinting + site use

With an ecological footprint of 4.3 Global hectares per person, Nagayama would need 43,000 ha to support 10,000 residents.

= 47 ha

= 43,000 ha
In other words, the area of Nagayama can support 11 average Japanese individuals.

Eco-Footprint Reduction
Is Necessary To Support More Residents

By supporting on-site energy and food production, water collection, and more efficient mobility, the new Nagayama plan reduces the average ecological footprint, allowing the site to support more people.

*Based on Heathrow, England, which has the lowest eco-footprint in the industrialized world (2.5 gha/person). At 2.6 gha/person, the area of Nagayama could support 11 residents, with zero ecological debt.
Nagayama Plan Metrics

**45%**
Development Areas

25% Built
10% Streets
25% Green Space
40% Unassigned

**20%**
Multi-Use Streetscape

50% Mobilit
40% Productive Landscape
10% Waste

Bento Machi Metrics

**75M²**
Building

**80M²**
Crop Field

**300M²**

**60M²**
Landscaped Paths

**3.5 Persons/Household**

Proposed Community Size:
1,155 Persons = 330 Households

With a physical footprint of 0.01 Hectares per resident, the bento-machi community concept can substantially reduce the eco-footprint of the residents by providing integrated systems on site.
35-65% of each community’s land area can be dedicated to productive processes that can reduce the residents’ footprints.

Each of the 10 ‘villages’ of different densities has a different balance of landuse between building footprint, ‘productive landscape’, streetscapes and common land (unassigned). This is a part of an analysis that a design project would need to undertake to understand the eco-system balance of design footprints.

Eco-footprinting + site use
Future research ideas for design, construction and urban systems

1. Test Bed for Future Prototypes:
   • Detailed design and implementation of an actual building prototype (US, Asia etc).
   • Design and testing of ecological-infrastructure such as greywater recycling system, and waste disposal.
   • Design development and testing of construction ecology system for housing design and assembly
   • Design and testing of smart technologies and imbedded information systems within buildings and infrastructure.

2. Research on:
   • Developing a dynamic interactive model of the carbon and energy metrics that accrue from urban design systems interaction.
   • Smart grids and associated energy technologies: identify the research questions.
   • Integrated and embedded technologies
   • Health and well-being related research and technologies in the home.
   • Suitability criteria and normative codes that advance sustainability and eco-design
   • Business enterprise concepts for sustainable development and ecological service providers (‘green dollar concept)

3. Dissemination
   • Establish on-line best practice clearinghouses that showcase examples of sustainable innovative urban systems.

The Future
Balancing Urban Housing with Infrastructure Systems:

The book is a product of a collaborative design research project at the Massachusetts Institute of Technology (MIT) School of Architecture and Planning and sponsored by Japan’s Sekai House. The research was intended to envision program and development directions for non-typical sustainable residential communities in the years 2030-2050. Much of the discourse about the design of sustainable communities and "eco-cities" has to date been premised on using previously undeveloped land. In contrast, this project and resulting publication focuses on the reworking of an existing environment—a more lively approach, given the extent of the world’s already built infrastructure.

At the center of the project is Tama New Town, close to Tokyo, and one of about thirty planned communities built by the Japanese government in the 1970s. The town currently presents a range of problems such as an aging population and the demolition of homes and buildings, particularly in the earlier phases of development. The problems that Tama New Town faces and which the research seeks to address are common to planned communities in many advanced nations and will soon have to be addressed by developing countries as well. The results of this work serve as a useful framework for future development and the means to balance urban systems and environmental agendas with new urban housing prototypes.

www.lulu.com/product/paperback/renewtown/11263249

Thank you
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