

# Designing for Sustainable Public Housing from Property Management and Financial Feasibility Perspectives

Kung-Jen Tu

**Abstract**—Many public housing properties developed by local governments in Taiwan in the 1980s have deteriorated severely as these rental apartment buildings aged. The lack of building maintainability considerations during project design phase as well as insufficient maintenance funds have made it difficult and costly for local governments to maintain and keep public housing properties in good shape. In order to assist the local governments in achieving and delivering sustainable public housing, this paper intends to present a developed design evaluation method to be used to evaluate the presented design schemes from property management and financial feasibility perspectives during project design phase of public housing projects. The design evaluation results, i.e. the property management and financial implications of presented design schemes that could occur later during the building operation and maintenance phase, will be reported to the client (the government) and design schemes revised consequently. It is proposed that the design evaluation be performed from two main perspectives: (1) Operation and property management perspective: Three criteria such as spatial appropriateness, people and vehicle circulation and control, property management working spaces are used to evaluate the 'operation and PM effectiveness' of a design scheme. (2) Financial feasibility perspective: Four types of financial analyses are performed to assess the long term financial feasibility of a presented design scheme, such as operational and rental income analysis, management fund analysis, regular operational and property management service expense analysis, capital expense analysis. The ongoing Chung-Li Public Housing Project developed by the Taoyuan City Government will be used as a case to demonstrate how the presented design evaluation method is implemented. The results of property management assessment as well as the annual operational and capital expenses of a proposed design scheme are presented.

**Keywords**—Design evaluation method, management fund, operational and capital expenses, rental apartment buildings.

## I. INTRODUCTION

### A. Research Background

THE housing prices in major cities in Taiwan have been skyrocketing in the past ten years. Housing products have become unaffordable to the majority. To solve this problem and provide affordable housing to the public, building 'public housing' has become an important policy for many local governments in Taiwan. However, the public housings the Taiwan Government built since the 1980s have mostly been for sale, and only less than 0.1% of them (around 6,400 units) have been for rent (for the disadvantaged minority) [1]. These

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existing rental apartment buildings have deteriorated severely as they aged, due to poor design, construction, and management. As a result, many residents consider public housings as NIMB (not in my backyard) facilities. In other words, building rental public housing is a new task for many local governments, and the most effective model for the development and property management of public housing estates has yet to be found.

### B. Public Housing Development Models Worldwide

Many countries in the world are experienced in building rental public housings. Their public housing development models are good references for local city governments in Taiwan. Based on the literature reviewed, this study sums up the development models of two experienced countries:

- 1) Netherlands' Third Party Development Model: In Netherlands, around 36% of the total housing stock are rental public housings, which were developed, constructed, operated, and managed by the independent third party 'Dutch Housing Associations' permitted and authorized by the Netherlands Government [2]. The government adopted a 'strategic asset management' approach and demanded Dutch Housing Associations to build public housing database and provide housing market information for the government to make effective public housing decisions [3]-[5]. As for the property management of public housing, Dutch Housing Associations and the industry have developed a mature outsourcing system as well as property management service quality evaluation mechanism to ensure the public housings are properly maintained [6].
- 2) Hong Kong's Government Development Model: In Hong Kong, around 30% of the total housing stock is rental public housings, which were planned by the government agency 'Housing Authority', and developed, constructed, operated, and managed by the 'Housing Department'. The 'Housing Department' has developed several systematic, standardized public housing designs, modular and industrialized construction methods, in order to reduce construction and maintenance costs [7]. As for the property management of constructed public housings, the 'Housing Department' outsources the operation and management tasks to external professional service providers and monitors their service quality periodically [8].

### C. Current Public Housing Development Model in Taiwan

Currently, local city governments in Taiwan have mostly adopted a three-phase model that outsources development,

project management, and property management tasks to external professional service providers. Yet many problems have occurred due to the lack of considerations of property management issues and financial issues from the whole building life cycle perspective. For example, in a constructed public housing estate developed by Taipei City Government and operated for five years, its operational and capital expenses simply could not be covered by the management fund allocated from rental income, due to not knowing how this public housing estate would be operated, managed, and maintained as well as not performing financial analysis during project design phase. In the long run, whether this public housing estate can be sustainably operated and maintained is highly questionable.

This study argues that public housing estates should be considered as important assets [9], and sustainable operational of public housing should be set as a primary goal. Throughout the whole building life cycle of a public housing project, five management aspects (financial management, planning management, design management, construction management, and property management) should receive attention comprehensively. Driven by this core concept, this study suggests that a design evaluation method be developed to assess the proposed design schemes from property management and financial feasibility perspectives during project design phase of public housing projects in order to inform clients of future operational and financial implications.

#### D. Research Objectives

To assist local city governments in making better decisions during the design phase of public housing projects in order to achieve sustainable asset management of public housing, this study intends to establish and present a design evaluation method to evaluate the proposed design schemes from property management and financial feasibility perspectives. To be more specific, the main objectives of this paper are:

- 1) To present the established design evaluation method which evaluates the proposed design schemes from (1) operation and property management perspective (three categories of criteria) and (2) financial feasibility perspective (four types of financial analyses);
- 2) To demonstrate how the design evaluation method works and the implementation results in an exemplary Chung-Li Public Housing Project developed by the Taoyuan City Government.

## II. SUSTAINABLE ASSET MANAGEMENT OF PUBLIC HOUSING

In the research field of 'sustainable construction', research efforts are mostly devoted to the topics such as developing systems to manage building performance based design, life-cycle assessment (LCA) systems, sustainable building rating and certification systems [10], [11].

In addition to the above topics concerned, this study argues that whether a building can sustain for a long depends also on the following factors and should be assessed accordingly:

- 1) Construction sustainability: A building can sustain for a long time if its major structure (structural and envelope systems) are durable and the building systems installed are

designed to have longer service lives. It is therefore critical to assess the construction sustainability of a building during detailed design phase.

- 2) Operation and property management sustainability: If the a building is properly planned for effective operation and property management, the building will be easier to operate and provide satisfied property management services with less manpower; and the building systems can be kept in a better shape. The building is thus expected to sustain for a longer time. It is important to make operation and property management plans during design phase and simulate on how the building will be operated, managed and maintained to ensure its sustainability.
- 3) Financial sustainability: A building can sustain for a long time if it can accumulate enough operational income and management fund to cover its operational and capital expenses during its long building life [12], [13]. Without sufficient management fund, a building may receive substandard maintenance, or be unaffordable for major equipment replacement or renovations. As a result, the building may deteriorate severely, and its life ends earlier. The possible operational income and management as well as operational and capital expenses during a building's long life should be estimated in early design phase [14], [15].

To achieve sustainable public housing, this paper suggests that the proposed design schemes be evaluated against the above three criteria.

## III. DESIGN EVALUATION METHODOLOGY INCORPORATING PROPERTY MANAGEMENT AND FINANCIAL FEASIBILITY CONSIDERATIONS

To deliver sustainable public housing, this paper develops a methodology and five-step flowchart for evaluating proposed design scheme from property management and financial feasibility perspectives during project design phase of public housing projects, as shown in Fig. 1.

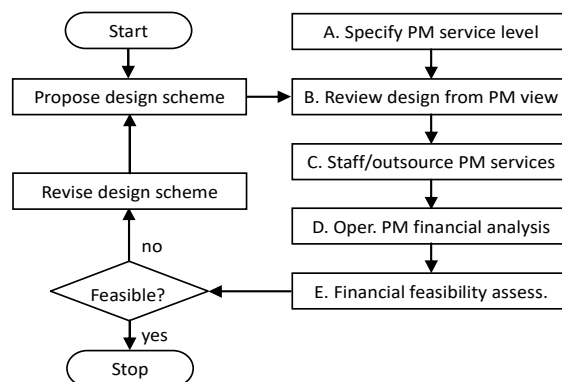


Fig. 1 Methodology for evaluating proposed design scheme from property management and financial feasibility perspectives

#### A. Specify Property Management Service Level

The local City Government has to decide the level and tasks of property management services required when a public

housing estate comes into operation. In a public housing estate or private condominium property, there are some typical operational and PM tasks conducted on a regular basis:

- 1) Administrative tasks dealing with public affairs and activities, tenant services, lease management, etc.
- 2) Security tasks dealing with entrance access control, periodic patrol, and emergency response, etc.
- 3) Cleaning tasks dealing with building cleaning in the public areas, garbage management, plant conservation, etc.
- 4) Building systems operation and maintenance tasks dealing with operation and preventive maintenance of various building systems, periodic building inspection, etc.

In addition, as a public housing estate ages, some other tasks may emerge as the government's spatial needs change, or the building and system components deteriorate and breakdown:

- 5) Major renovations of building structures (external walls, roofs) or interior (layouts and finishes).
- 6) Replacement of major building systems and components.
- 7) Repair or replacement of fixtures, furniture, equipment or appliances within apartment units.

#### *B. Evaluate Proposed Design Scheme from PM Perspectives*

The proposed design scheme is evaluated from the following three property management perspectives (future property operation, management, and maintenance scenarios):

- 1) Spatial appropriateness (location, size and functionality):
  - Lobby of each building
  - Common facilities: such as multi-function room (activity, conference), gymnasium, library, etc.
  - Commercial spaces: retail stores, shops
  - Social welfare: daycare, domestic violence center, etc.
  - Property management service spaces: management and service center, central control room, guard house
- 2) People and vehicle circulation and control (circulation path, security, functionality, control point):
  - Tenants, guests, outsiders
  - Property management staff
  - Service personnel (postman, deliveryman, garbage collectors, contractors, technicians, medical staff)
  - Tenant vehicles (cars, motorcycles, bikes)
  - Service vehicles (trucks for equipment, construction materials, ambulance, moving, garbage collection, etc.)
- 3) Property management working spaces (location, size, work flows, convenience):
  - Service and management center and back office
  - Security guard house and back office
  - Cleaning storage room and back office
  - Construction material and spare part storage room

#### *C. Staff and Outsource Property Management Service*

Once the property management service tasks are specified, and a proposed design scheme deems operational, economical full time staff need to be planned and assigned with responsible areas on building site and specific regular PM services/tasks. The followings are the typical full time staff needed:

- 1) Administrative on-site manager and assistants
- 2) Security guards

- 3) Cleaning workers
- 4) Building systems operation and maintenance technicians

In addition, there are certain PM services and tasks requiring certain specialties or are only conducted on a seasonal or annual basis, and therefore are typically outsourced to specialized companies:

#### *D. Operational & Property Management Financial Analysis*

Once the required property management services and tasks are staffed and outsourced, the following four types of financial analyses are performed to assess the long term financial feasibility of the proposed design scheme:

- 1) Operational and rental income analysis: Estimating the total annual operation and rental income of the whole public housing from various sources such as residential rental income, entitlement premium for outsourced parking operation, and rental income from other facilities.
- 2) Management fund analysis: Estimating the total annual management fund allocated from the residential and other facilities' rental income and used to cover all the operation and property management expenses of the public housing during its building life.
- 3) Regular operational and PM service expense analysis: Estimating the annual operational expenses incurred by regular PM services and operations. Operational expenses cover the utility (water, electricity, gas) used in common facilities and public areas. Regular PM service expenses covered the regular services outsourced to PM service provider and specialized companies.
- 4) Capital expense analysis: Estimating the expenses of (1) major renovations, or repairing and replacing major building systems that may emerge during the building life of a public housing; and (2) repairing or replacing fixtures, furniture, bathroom equipment, and air conditioners within apartment units.

#### *E. Financial Feasibility Assessment*

The operational and property management financial analyses performed in the previous section are summarized to reveal the financial sustainability of the proposed design scheme of a Public Housing project. It is important to examine whether the total annual management fund is sufficient to cover the total annual operational and capital expense, or to realize the magnitude of possible deficit. The proposed design scheme will not be financially sustainable in the long run if the income-expense deficit is huge.

If a proposed design scheme is not deemed financially feasible, certain strategies which can increase the operational income or management fund, or decrease the operational or property management service expense of the proposed design scheme should be further offered to the city government to remedy the financial deficit. Finally, the proposed design scheme may need to be further revised accordingly to improve its financial performance.

#### IV. DEMONSTRATION CASE

##### A. The Subject

The subject is an ongoing Chung-Li Public Housing project developed by the Taoyuan City. The project is in its planning phase and outsourced to be managed by a Professional Construction Management (PCM) Team. The author is a member of this PCM team and provides property management related consultancy. Some basic information about the Chung-Li Public Housing project are as follows:

- 1) Site: The land size is roughly 25,000 m<sup>2</sup>, and located in the Chung-Li District of the Taoyuan City. The site is surrounded by residential zones, and close to two commercial zones (one to the east, the other to the south) offering vital functions in the neighborhood (Fig. 2).
- 2) Land use regulations: The site is located within residential zone, for which the regulated maximum building coverage ratio is 60% and floor area ratio is 200%.
- 3) Rooms: roughly 900 units will be offered, 45% one bed room (1BR, 40 m<sup>2</sup>), 40% two bed room (2BR, 60~65 m<sup>2</sup>), 15% three bed room (3BR, 80 m<sup>2</sup>).
- 4) Facilities: One the first floor, common facilities such as library, gymnasium will be provided for tenants; and commercial and social welfare facilities provided for rent.
- 5) Parking: roughly 890 car parking spaces and 890 motorcycle parking spaces will be offered in the basements. The parking facility will be outsourced to a professional parking management company for parking facility operation and maintenance.



Fig. 2 The site location and zoning map around the site

##### B. Specify Property Management Service Level

The Taoyuan City Government has decided to outsource the property management task of the Chung-Li Public Housing Estate to a professional service provider through public procurement process. The city government also specifies the service level as well as the tasks of property management services to be performed by the selected service provider. The

following PM tasks will be conducted on a regular basis:

- 1) Administrative: Tenant services and code of conduct, community public affairs, common facilities reservation and management, and tenancy management.
- 2) Security: 24-hour entrance access control (main gates and parking entrances/exits), periodic patrol throughout the whole property.
- 3) Cleaning: Floors and windows in public areas, water tanks, building exterior walls, garbage collection and recycling, plant trimming and conservation, and outdoor public areas disinfection.
- 4) Building Systems operation and maintenance: preventive maintenance of various building systems (HVAC, elevator, fire safety, power, telecommunication, security, plumbing, outdoor facilities), periodic building safety inspection, as well as repair and replacement of fixtures and equipment within apartment units. In addition, the Taoyuan City Government will provide kitchenware, bathroom fixtures, basic furniture (closets, bed frames), air conditioners, light fixtures, and washer in each unit. The following PM services (repair or replacement) will be provided upon request by tenants:
- 5) The repair or replacement of fixtures, furniture, equipment or appliances within apartment units (service providers provides repair labor, city government provides fixture, equipment, and spare parts).

##### C. Evaluate Proposed Design Scheme from PM Perspectives

The architect from the PCM team proposed a design scheme of Chung-Li Public Housing to the Taoyuan City Government, as shown in Figs. 3~6. Eleven buildings ranging between 10 and 13 floors are placed on the site, and two levels of basements are designed to provide car and motorcycle parking as well as mechanical rooms for various building systems. The total floor area is 81,000 m<sup>2</sup> for floors above ground, and 37,000 m<sup>2</sup> for two basement floors.

The proposed design scheme is evaluated from the following three property management perspectives (future property operation, management, and maintenance scenarios):

- 1) Spatial appropriateness (location, size and functionality)
- 2) People and vehicle circulation and control (circulation path, security, functionality, control point)
- 3) Property management working spaces (location, size, work flows, convenience)

After the design evaluation, the author proposed the following design revision in order to achieve more effective property management services and minimize service staff:

- 1) Centralized service and management center (A in Fig. 4), which provides service counter, storage room (for mails, parcels, and goods), meeting room and back office for administrative staff.
- 2) Security guards placed at two critical locations, one in Central Control Room (B in Fig. 4) and Guard House (C in Fig. 4), providing effective security monitoring and protection.

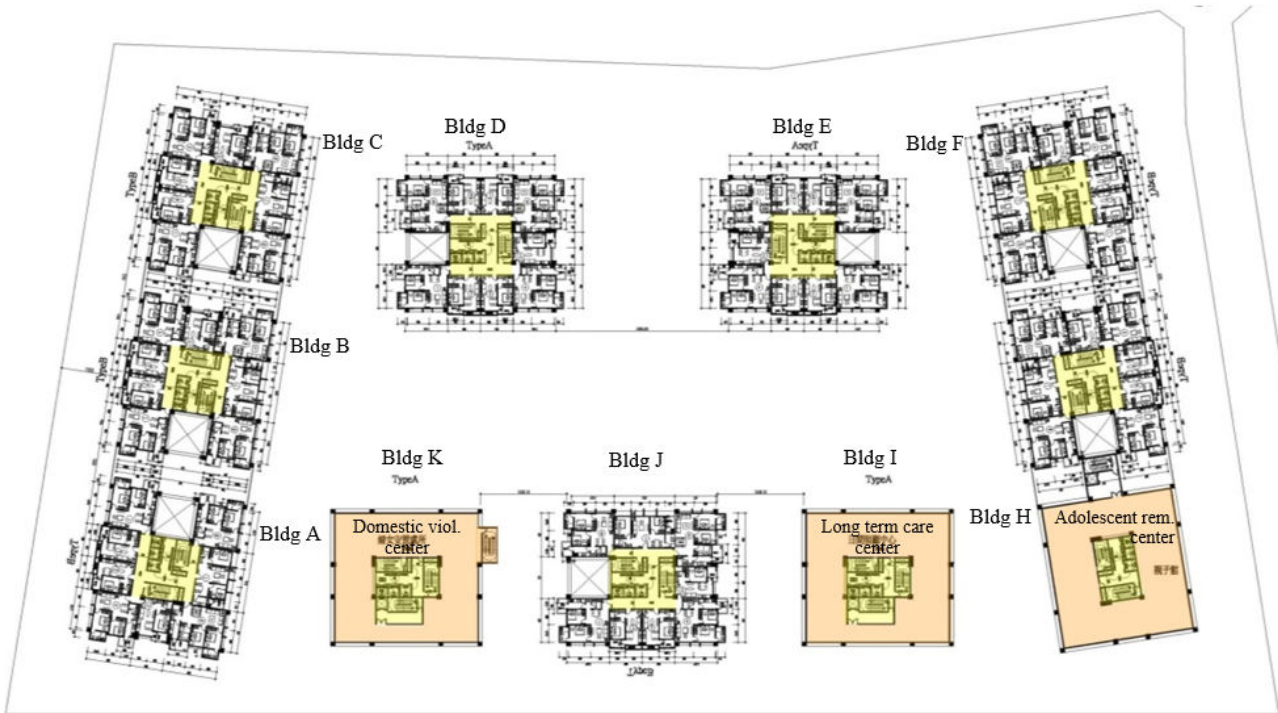


Fig. 3 The second floor plan of the Chung-Li Public Housing design scheme



Fig. 4 The site plan and first floor plan of the Chung-Li Public Housing design scheme



Fig. 5 The B1 floor plan of the Chung-Li Public Housing design scheme



Fig. 6 The exterior view of the Chung-Li Public Housing design scheme (viewed from the north-east corner)

- 3) Common facilities are placed adjacent to the service and management center for shorter distance, easier access and effective services.
- 4) Commercial facilities are placed on the north and east sides of the site for being closer to the existing commercial zones and stores in the neighborhood and consumers.
- 5) Social welfare facilities are placed on the west and south sides of the site for the privacy they require.
- 6) Separate vehicular entrance (two blue arrows in Fig. 4) and exit (one red arrow in Fig. 4) design to reduce the transportation impact on adjacent roads. Since the parking lots in the basements will be outsourced to professional parking management company, no security guards are required at the entrances or exits to minimize security staff.
- 7) Unloading parking spaces are placed close to the elevator hall ways for easy transport in the basements.
- 8) Garbage rooms are placed adjacent to elevator hall ways and unloading parking spaces for easy garbage collection.

- 9) Enough storage rooms placed in the basements for storing materials, spare parts, cleaning equipment and tools, etc.

#### *D. Staff and Outsource Property Management Service*

Among the PM services and tasks specified in above (B), some are required to be conducted on a regular and daily basis. These PM services and tasks will be outsourced to a profession PM service provider and the following four types of full time staffs (on-site) are planned:

- 1) Administrative staff: One on-site manager and four secretaries are allocated and stationed in the community management office to perform the administrative tasks and services to the tenants.
- 2) Security staff: Six security guards in three shifts are dispatched on two locations (central monitoring and control room, guardhouse) to provide 24-hour security services (monitoring, patrol, and emergency response).
- 3) Cleaning staff: Six cleaners are assigned to provide daily cleaning services (floor cleaning of all common facilities and elevator hallways on all floors in eleven apartment buildings; garbage collection and recycling in the basements).
- 4) Building systems operation and maintenance technician: One full time on-site technician is allocated to perform preventive maintenance or repair of various building systems (HVAC, power, telecommunication, plumbing, outdoor facilities) as well as repair and replacement of fixtures and equipment within apartment units request by tenants.

The rest of the PM services and tasks may require certain

specialties or are only conducted on a seasonal or annual basis, and therefore are to be outsourced to specialized companies:

- 5) Annual inspection services on building safety and fire safety equipment.
- 6) Preventive maintenance services of elevator, fire safety, security systems.
- 7) Cleaning services: garbage removal and recycling, water tanks and external wall cleaning, outdoor disinfection, sewage treatment, and plant conservation.

#### E. Operational & Property Management Financial Analysis

Based on the property management services planned for the Chung-Li Public Housing Estate, four types of financial analyses are performed to assess the long term financial feasibility of the proposed design scheme:

- 1) Operational and rental income analysis: Table I A shows the total annual operation and rental income of the whole public housing is NTD (New Taiwan Dollar) 125,863,680, consisting of residential rental income (83%), entitlement premium from outsourced parking management company (7%), and rental income from other facilities (10%).
- 2) Management fund analysis: Part of the residential and other facilities' rental income are allocated as the 'management fund' to cover the operation and maintenance expenses of the public housing during its life cycle. As shown in Table I B, the total annual management fund of the whole public housing is NTD 14,224,440 (11.3% of total annual operational and rental income), consisting of management fund from residential rental income (93%), and from rental income from other facilities (7%).
- 3) Regular operational and PM service expense analysis: Annual operational expenses incurred by regular PM services and operations are estimated. Table II shows that, on average, the total monthly regular operational and PM service expense is NTD 1,279,500/month; among which the regular PM service expense is NTD 979,500/month

(Table II A; 77%), and the regular operation expense is NTD 300,000/month (Table II B; 23%). The resulting total annual regular operational and PM service expense is NTD 15,354,000/yr.

- 4) Capital expense analysis: Since the major building systems have not been designed and specified, the capital expenses of replacing these building systems or major renovations during the life cycle of public housing are unable to estimate at this stage. Only the capital expenses of replacing fixtures, furniture, equipment, and air conditioners within apartment units are estimated. Table II C shows that, on average, the total monthly capital expense replacing fixture or equipment within apartment units is estimated to be NTD 750,000/month, resulting in a total annual capital expense of NTD 9,000,000/yr (roughly NTD 10,000/unit-yr).

TABLE I

FINANCIAL ANALYSIS I: OPERATIONAL INCOMES AND MANAGEMENT FUND OF THE CHUNG-LI PUBLIC HOUSING ESTATE (UNIT: NTD NEW TAIWAN DOLLAR)

A. Rental Income (including management fee)						B. Management Fund					
Category	Type	Quantity (unit or m <sup>2</sup> )	Rent (NTD/mth)	Annual Inc. (NTD/yr)	Note	Category	Type	Quantity (unit or m <sup>2</sup> )	Rent (NTD/mth)	Annual Inc. (NTD/yr)	Note
Residential	1BR	410 units	7,000	34,440,000	Monthly rent 120 NTD/ m <sup>2</sup> (70~80% market price)	Residential	1BR	410 units	900	4,428,000	Monthly management fee 15 NTD/m <sup>2</sup>
	2BR	346 units	10,800	44,841,600			2BR	346 units	1,350	5,605,200	
	3BR	151 units	14,000	25,368,000			3BR	151 units	1,750	3,171,000	
	<b>Sub-total</b>	<b>907 units</b>		<b>104,649,600</b>			<b>Sub-total</b>	<b>907 units</b>		<b>13,204,200</b>	
Parking	Car	890 units	2,000	8,544,700	Outsourcing; City Gov. collect 40%	Parking	Car	890 units	0	0	Outsourcing; City Gov. no income here
	Motorcycle	890 units	100	427,200			Motorcycle	890 units	0	0	
	<b>Sub-total</b>			<b>8,971,200</b>			<b>Sub-total</b>			<b>0</b>	
Retails and Social Welfare Facilities	Retail shops	1,384 m <sup>2</sup>	180/m <sup>2</sup>	3,013,920	Monthly rent 180 NTD/m <sup>2</sup> (70~80% market price)	Retails and Social Welfare Facilities	Retail shops	1,384 m <sup>2</sup>	15/m <sup>2</sup>	251,160	Monthly management fee 15 NTD/m <sup>2</sup>
	Public day care center	1,431 m <sup>2</sup>	180/m <sup>2</sup>	3,116,880			Public day care center	1,431 m <sup>2</sup>	15/m <sup>2</sup>	259,740	
	Adolescent rem. center	1,766 m <sup>2</sup>	180/m <sup>2</sup>	3,846,960			Adolescent rem. center	1,766 m <sup>2</sup>	15/m <sup>2</sup>	320,580	
	Long term care center	795 m <sup>2</sup>	180/m <sup>2</sup>	1,731,600			Long term care center	795 m <sup>2</sup>	15/m <sup>2</sup>	144,300	
	Domestic viol. center	245 m <sup>2</sup>	180/m <sup>2</sup>	533,520			Domestic viol. center	245 m <sup>2</sup>	15/m <sup>2</sup>	44,460	
	<b>Sub-total</b>			<b>12,242,880</b>			<b>Sub-total</b>			<b>1,020,200</b>	
	<b>Total</b>			<b>125,863,680</b>			<b>Total</b>			<b>14,224,440</b>	

TABLE II  
FINANCIAL ANALYSIS 2: OPERATIONAL AND CAPITAL EXPENSES OF THE CHUNG-LI PUBLIC HOUSING ESTATE (UNIT: NTD)

Type	Item	Quantity	Unit cost	Monthly Expense	Notes
<b>A. Regular PM Service Expense</b>				<b>979,500 NTD/mth</b>	<b>Sub-total</b>
<b>I. Personnel</b>				<b>668,000 NTD/mth</b>	<b>Sub-total</b>
1. On-site manager	Supervision	1 person	55,000 NTD/mth	55,000 NTD/mth	Always two persons on duty
2. Administrative	Community admin.	4 person	40,000 NTD/mth	160,000 NTD/mth	
3. Security	Guard, patrol	6 person	36,000 NTD/mth	216,000 NTD/mth	24 hours, 3 shifts
4. Cleaning	Floor, wall, garbage	6 person	32,000 NTD/mth	192,000 NTD/mth	
5. Bldg technician	Bldg equip. inspection	1 person	45,000 NTD/mth	45,000 NTD/mth	On site; maintenance
<b>II. General Services</b>				<b>25,000 NTD/mth</b>	<b>Sub-total</b>
1. Phone	Administrative use		3,000 NTD/mth	25,000 NTD/mth	
2. Office supplies	Administrative use		10,000 NTD/mth		
3. Network	Administrative use		1,000 NTD/mth		
4. Drink fountain	Public area		1,000 NTD/mth		
5. Festival activity	Miscellaneous		10,000 NTD/mth		
<b>III. Cleaning</b>				<b>37,500 NTD/mth</b>	<b>Sub-total</b>
1. Garbage clean up	Collect and remove	36 units	36,000 NTD/mth	37,500 NTD/mth	
2. Toilet paper	Public toilets	3 toilets	500 NTD/mth		
<b>IV. Elevator maintenance</b>				<b>144,000 NTD/mth</b>	<b>Sub-total</b>
1. Elevators	Routine check-up	36 units	4,000 NTD/unit	144,000 NTD/mth	
<b>V. Security &amp; Fire Safety Systems Maintenance</b>				<b>18,000 NTD/mth</b>	<b>Sub-total</b>
1. Security system	Access control, CCTV		6,000 NTD/mth	18,000 NTD/mth	
2. Fire safety system	Alarm, smoke detector		12,000 NTD/mth		
<b>VI. Periodic Inspection and Maintenance</b>				<b>87,000 NTD/mth</b>	<b>Sub-total</b>
1. Annual inspection	Public & fire safety	Once/yr	54,000 NTD/yr	4,500 NTD/mth	
2. Insurance	Public accident	Once/yr	6,000 NTD/yr	500 NTD/mth	
3. Water tank cleaning		22 tanks	1,500 NTD/tank	5,500 NTD/mth	Twice a year
4. Disinfection	Public area	Twice/yr	9,000 NTD/each	1,500 NTD/mth	Twice a year
5. Exterior wall cleaning	Bldg external walls	Once /3 yr	900,000 NTD/each	25,000 NTD/mth	
6. Sewage treatment		2 reservoir	240,000 NTD/each	40,000 NTD/mth	Once/yr
7. Plant conservation	Fertilize, worming		40,000 NTD/each	10,000 NTD/mth	Once/season
<b>B. Regular Operation Expense</b>				<b>300,000 NTD/mth</b>	<b>Sub-total</b>
1. Electricity	Public area use	25,000m <sup>2</sup>	12 NTD/m <sup>2</sup>	300,000 NTD/mth	Rough estimation
2. Water	Public area use				
<b>A + B: Regular Operational and PM Services</b>				<b>Monthly Total 1,279,500 NTD/mth</b>	<b>15 NTD/m<sup>2</sup>-mth</b>
				<b>Annual Total 15,354,000 NTD/mth</b>	
				<b>Annual Total 16,889,400 NTD/year</b>	<b>+10%</b>
<b>C. Capital Expense within Apt. Units</b>				<b>750,000 NTD/mth</b>	<b>Total</b>
1. Light fixture, lamps			9,000,000 NTD/yr	750,000 NTD/mth	10,000 NTD/apt. unit;
2. Furniture, closet					10 NTD/m <sup>2</sup> -mth;
3. Bathroom equipment					
4. Kitchenware					
5. Air conditioner					

TABLE III  
FINANCIAL ANALYSIS SUMMARY

Annual Income	Total Income (NTD/yr)	Income per Unit (NTD/unit)	Income per Fl. Area (NTD/m <sup>2</sup> )
Apartment rental	104,649,600	115,253	4,229
Parking premium	8,971,200	9,880	363
Retail etc. rental	12,242,880	13,483	495
<b>Total</b>	<b>125,863,680</b>	<b>138,616</b>	<b>5,086</b>
Management Fund	Total Income (NTD/yr)	Income per Unit (NTD/unit)	Income per Fl. Area (NTD/m <sup>2</sup> )
<b>Total</b>	14,224,440	15,666	575
(11.3% of annual income)			
Annual Expense	Total Expense (NTD/yr)	Expense per Unit (NTD/unit)	Expense per Fl. Area (NTD/m <sup>2</sup> )
Regular operation, PM service (A+B)	16,889,400	18,601	683
Capital expenses within apt units (C)	9,000,000	9,912	364
Capital expenses of major bldg systems		Not estimated	
<b>Total</b>	<b>25,889,400</b>	<b>28,513</b>	<b>1,047</b>



#### F. Financial Feasibility Assessment and Strategies

The operational and property management financial analyses performed in the previous section are summarized in Table III which reveals the financial sustainability of the proposed design scheme of the Chung-Li Public Housing project. As shown in Table III, the total annual management fund (NTD 14,224,440) is insufficient to cover the total annual operational and capital expense NTD 25,889,400 (not including capital expenses of replacing major building systems), incurring a 45% deficit. If the capital expenses of major building systems are included, the deficit will be even larger. In other words, the proposed design scheme is not financially sustainable in the long run. Certain strategies are proposed to the city government to relieve the problem:

- 1) Increase management fund: include the entitlement premium from the parking management company (NTD 8,971,200) into the management fund which will reduce the deficit to 10%. But on the other hand, this will defer the payback time of the initial construction investment.
- 2) Minimize provisions within apartment units: provide only basic kitchenware or bathroom fixtures, but not furniture or air conditioners, within apartment units to cut down the initial investment and future capital expenses.
- 3) Adopt the concept of 'circular economy': procure rental and maintenance services from major furniture or air conditioner dealers to provide necessary furniture or air conditioners within apartment units while reducing their future capital expenses.
- 4) Reduce PM service staff: reduce service level, or adopt more intelligent or smart technologies/equipment to reduce the administrative, cleaning, and security staff, and thus the expense of regular PM services.

#### V. CONCLUSION

To assist the local governments in delivering sustainable public housing, this paper presents a method for evaluating the proposed design schemes from property management and financial feasibility perspectives during project design phase of public housing projects. The design evaluation results (i.e. the property management and financial implications) of proposed design schemes will be informed to the client (the government) for reference and further improvements on design decisions. It is proposed that the proposed design schemes be evaluated from two main perspectives: (1) Operation and property management perspective: three criteria (i.e. spatial appropriateness, people and vehicle circulation and control, property management working spaces) are used to evaluate the 'operation and PM effectiveness' of a design scheme. (2) Financial feasibility perspective: four types of financial analyses (i.e. operational and rental income analysis, management fund analysis, regular operational and property management service expense analysis, and capital expense analysis) are performed to assess the long term financial feasibility of a design scheme. The ongoing Chung-Li Public Housing Project developed by the Taoyuan City Government is used as a demonstration case to show how the devised design

evaluation method can be applied, and the evaluation results and strategies for design improvements are presented.

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