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Resource Generating Residential Towers

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Abstract

The emphasis of this study is to contribute to resolve the emergent problem of limited space and resources in the City centres due to the continuous increase of centralized population in urban areas. The proposed solution is residential towers within the city centres dedicated to providing resources of space, energy, food and water to its surrounding community.

Through a design based research, Resource Generating Residential Towers were investigated in two contrasting locations and climates (London & Cairo). This offered diverse research parameters such as optimum passive strategies, tower height, suitable resources and yields. Furthermore the variation between resident's resources demands, living patterns and acceptance of this project type and its required community contribution.

Research Conclusions suggest that Cairo's project is more effective in terms of Energy production to the community, relying on the assistance of the local climate and the relative low community energy demand. However London's project is more effective in terms of Rainwater harvesting and its consequence on agricultural production. Yet both projects have positive impacts on their communities in terms of increased Space.

Keywords: Resource, Generate, Tower, London, Cairo

1 Introduction

Projections of world population show an inevitable growth. United Nations Department of Economic & Social Affairs, 2004 Show a medium scenario for population growth of 150% by year 2050. However projections are expected to skyrocket by year 2300 up to 600% of a total 36.4 billion people in the worst case. Furthermore, whether the presence of population growth is obvious or not, cities attract population from its surroundings constantly due to various qualities, therefore the overpopulation predicament affects the world today (UNICEF, 2012).

Observing the population's pattern of living, it's clear that employees in the urban areas usually prefer residence in city centres surroundings to achieve a safer life style while remaining a close approach to the city centre, this results in a massive ecological footprint due transportation (Environment Agency, 2009). Generally Cities in America and Europe have higher ecological footprint due to the absence of the compact cities concept. Other cities such as Hong Kong have minimal footprints due to minimization of transportation needs (Newman & Kenworthy, 1989).

Resulting from urban areas population, great amount of resources are provided; but the strained resources are continuously decreasing due to limited area for development which overtakes areas reserved for resource production as shown in Cities such as Cairo (Rimal,

2001) and London, where farmland on the Greater London fringe is in a rapid state of decline due to development pressure (Greater London Authority, 2002). Moreover, the delivered resources are decreased due to transportation losses where Europe losses are close to 30% (Gustavsson & Cederberg, 2011).

2 Required design steps of a Resource Generating Residential Tower

2.1 Step 1: In order for the Concept of the Resource Generating Residential Towers to ideally work, initially a decrease in the towers resources consumption must occur. This minimization can be implemented via passive and active design strategies. Preliminary design strategies for the tower itself and the individual apartments are dependent on project location and climate as concluded from the investigated Eco tower case studies summarized in table 1.

Table 1: Overall Conclusions

Comparison Point	LONDON, UK	CAIRO, Egypt
Orientation	Main orientation should be South or South-West for maximum solar gains, however summer shading instalments may be required.	Main orientation should be North or North-west for maximum cool winds access; however buffer zones maybe installation for rare cold wind.
Users	Organized by category: single units, family units, luxury apartments	
Zoning	Residents of different apartment types should be categorized separately but located near commercial & office zone, while sharing public areas (gardens)	
Vertical Approach	Lifts & stairs should be centralized in the North East zone as it's the coldest area during winter.	Lifts & stairs should be centralized in the South East zone as it's the hottest area during summer.
Vertical Landscaping	Private gardens+ semi-public sky parks+ continuous landscaping providing shade in summer+ buffer zones for wind in winter & possibility for rain harvesting.	Possibility of Private gardens+ semi-public sky parks+ Continuous landscaping providing shade in summer.
Plan shape	Possibly Semi-Oval shape long side towards South ordination.	Possibly an arc shape open to the North Orientation.
Passive strategies	Natural illumination and Ventilation can be introduced deep inside the building by using light wells. Stack ventilation & thermal mass can also aid the design strategy.	
Potential Renewables	Solar thermal+ PV+ Ground Source Heat Pumps (GSHP) +Combined Heat and Power (CHP) + Biomass.	

2.2 Step 2: A detailed analysis of available resources and potentials in the bioregion of the location is required in order to make use of any opportunities. This includes a study of the location, surrounding natural and built environment, their potential and the climate.

Table 2: Comparison between Renewables for London Project

Comparison Point	Photovoltaic	Solar thermal	Airborne Wind Tech
Potential Availability	UK: average temperature 11°C and average Sunshine hours 1,461/yr		Constant and high wind power available (at high altitudes)

	EGY: average temperature 27.5°C and average Sunshine hours 3416/yr		
Technology Type Used	Multicrystalline	UK: Evacuated Tubes EGY: Flat Plate	Airborne Wind Technology
Best Practice	30-40º Tilt--No Overshadowing Min. 8-10 m2 for a grid connected home		This system doesn't require space or location for optimum use.
Energy Yield	4kWp=3434 10kWp=8585 50kWp=42925	582 kWh/m2 provide 100% of 2 bed flat DHW	$0.02 per KWh
Capital Costs	£11,000-13,000	£3,000 - £5,000	
Environmental Impact	Fossil fuel Used in production. Large area required for Large production.		Overshadowing
Proposal	Grid connection fulfil generation concept Possible façade instalment if required Large scale production centralized zone		Investment in Airborne Wind turbines

Table 3: Continued Comparison between Renewables for London Project

Comparison Point	Biomass	CHP	GSHP
Potential Availability	Agricultural Waste. Wood & Scrubs	Agricultural Waste. Wood & Scrubs	Available area due to Dug foundation
Technology Type Used	Direct Combustion Central System	CCGT CHP system	100m Borehole
Best Practice	Depending on the fuel used best practice areas are provided in table 7	Best used for large scale production with high & constant demand of energy	Heating needs to be continuously on Explore Space heating by Under floor heating
Energy Yield	Average Wood 15 MJ/kg Straw & Other waste 15 MJ/kg	Heat Output 40.5 MW Electrical Output 53 MW Fuel Input 134.3 MW	Provided in design section
Capital Costs		£ 600,000	£9,000 to £17,002 (for average home)
Environmental Impact	Higher carbon emissions	Requires Constant heat energy demand. Low carbon savings	noise, overshadowing & required large spaces
Proposal	Use central Biomass boiler. Fuel used is fast growing trees, shrubs & waste. Required labour from residence is to participate in the gardening process.	Use of large system CHP for community generation purposes. Use Excess heat for S.H. or communal activities Waste & sewage will be used as system fuel.	Use borehole system taking advantage of dug foundations. Use under floor heating.

2.3 Step 3: Simulations must be undertaken via energy analysis and thermal conditions software (IES & Ecotect) to determine validity of strategies and estimations of energy consumptions. Based on the tower consumption and Overshadowing simulations and possible tower production increase via the use of heighted facades, the ideal tower height can be determined based on its location. In the two designed projects, overshadowing is particularly a problem in London, additionally overshadowing is inevitable in both locations in winter.

2.4 Step 4: Via various simulations and estimated energy production calculations, the energy yield, carbon and financial savings capital and running costs of different generation systems were identification while using in best practice scenario. This suggested PV, Solar thermal, Biomass and CHP in London's project case. However Cairo's project case biomass was omitted due to decreased heating demand. The project is 42 floors, 92100m2 total area with 8.6 acres for V.F.

Table 4: Energy Coverage and excess feed to the surrounfing community

Point of Comparison	London, UK	Cairo, Egypt
Total Cost of systems and Running costs	£ 3,585,851	£ 3,100,400
CO2 reduction	840 Tones/yr	
Average coverage Demand+	100%+	100%+
• Excess Energy for Heating	1,327,126kWh/yr	877,042kWh/yr
• Excess Energy for Cooling		888,034kWh/yr
• Excess Energy for Electricity	812,637kWh/yr	96,835kWh/yr
Average Electricity	3,300kWh	2,280kWh
Average Cooling		5,320kWh
Average Gas	16,500kWh	
Possible to cover (electricity)	247 Homes	425 Homes
Possible to cover (cooling)		170 Homes
Possible to cover (heating)	81 Homes	950 Homes
Average payback period	17.5 years	19 years

This method should be applied with other resources of food, water and building materials.

Food Production generation through Vertical Farming can Provide 2 or 4 Times more than Conventional Farming depending on the Crop, in some cases 30 times more. (Despommier, 2010). Assuming an average advantage of 3 times, these are the results:

Table 5: Land required to produce different kinds of diet in a vertical farm (Lugenbehl, 2007) (Despommier, 2010)

For a person eating the standard diet of a mix of animal and plant foods 1 acre of land is required to produce one person's food on a continuing basis.
For a person eating a diet of plants, eggs, and dairy, only 0.1 acre is required to produce one person's food on a continuing basis.
For a person eating a totally plant-based diet, only 0.05 acre is needed to produce that person's food on a continuing basis.

Table 6: Vertical farming yields and coverage

			for optimum coverage	
8.6 families	on mixed animal & plant Diet	2.15%	400 acres remaining	234floors
86 families	on Plants, eggs & dairy Diet	21.5%	40 acres remaining	18 floors
172 families	on a plant based Diet	43.5%	20 acres remaining	6 floors

The feasibility of the food production in the tower can suffice the residence; however this depends on the adopted diet of the residence within the tower. Best practice outlined in Table 7.

Step 5: Redesigning and troubleshooting of errors in the design must occur (in a decreased amount as the project becomes enhanced with feedback) via a questionnaire with the community to discover their preferences.

London's questionnaire sample wasn't expressive of the community due to limitations of willingness to participate in this study resulting in only 8 participants, consisting of students and families. Cairo's questionnaire sample on the other hand consisted of a total of 34 participants.

It was concluded that Families and retired individuals are ideal as residence in the proposed project due to their willingness to participate in the towers generation activities. Non-permanent residence (students) weren't interested in the idea for their current homes; therefore they shouldn't be the focus residents in such tower.

Through the questionnaire it's revealed that in Cairo food is the highest expenditure in the average family. Besides residence concerns with locally generated food health issues, cost is mainly why people were eager for local food production. In London's case Transportation and food is the highest expenditure, therefore depending on the location, the same project requires different generated resources intensified in order to meet the demand of its residence.

London questionnaire participates generally prefer a distributed approach to their resource supply, on the other hand Cairo residence prefer a communal approach to their resource generation supply. However London participant who choose the communal approach are willing to give more time and effort than Cairo participants mainly due to cultural difference.

3 Ideal conditions for the project

Table 7: Ideal Setting for Resource Generating Towers

Environment	Dense Urban Central Residential Area
Residents profile	Families and Retired individuals.
Residence Preferences	Locations differ resident's preferences due to Cultural difference. Communities reviewed in the study are positive about the project Concept. Depending on the demand of the people certain resources should be intensified in the tower on the account of others. London's community prefers distributed resource supply which can compromise concept of project. Conversely Cairo's community prefers a centralized resource supply.
Height	Relevant to Location to minimize overshadowing. However enviable overshadowing in winter is expected. Yet to be determined: Ideal compromise between resource generation due to height and construction cost.
Resource Generation	Backup connection to the mains feed. Each resource generation strategy must rely on multiple methods of generation
Community feed	Through Physical connection to a designed radius of generation (beside the feed in tariff) to make use of both heat and electrical surplus generation. Yet to be determined: Additional research on costs of physical connections of Pipes (heating connections) and Cables (electrical connection).
Energy Resource	Initially minimization of consumption is required Via A++ rated appliances, passive and active design strategies. It's vital to provide energy resource through multiple means. Energy Production must be centralized to maximize production

	and minimize losses. Facades should be modelled to host energy production systems, if additional energy is required. Usage of waste materials and sewage in the energy generation process particularly in CHP & Biomass systems.
Food Resource	Covering the demand possibility depends on the resident's diet shown in Table 6. Vertical Farming method through 3 sections 1.First floors for dedicated farming oriented south, 2.Indoor farming where directs natural illumination not available and 3. Distributed private apartment gardens. Ground floor Market for distributing the tower's Resources providing financial profit & employment.
Space Resource	Effective In city centres locations, however financial savings are determined based on individual location renting market.
Water Resource	Initially minimization of consumption is required through low flow toilets and occupants patterns. Building shape must maximize water collection through its design. Storage tanks must be provided in two methods, separate apartments mainly for private gardens irrigation and main storage tanks in a modular system in the ground floors. excess water from apartments must flow to the main tanks.
Building Material Resource	Advised to be extracted from the available location materials. Advised to make use of the dug materials after an analysis of the soil and its building possibilities.

4 Possible advancement in or future research:

From these outlined conclusions there is an opportunity of gathering the collected data and simulations of designed projects and formulating a Design Aid Software that can quantify the production of resources and provide best practice scenarios based on certain design project preferences feed into the system. This simulation software will be eventually cross referenced to already built projects where a resource generation was implemented and simulations based on these data will be carried out and compared to perceive the margin of error for future correction.

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