

ARCHITECTURAL ENGINEERING SENIOR
THESIS PRESENTATION

HAMAD ALRAHMANI

Fall 2010

Pennsylvania State University



MURUR MIXED-USE COMPLEX
AJMAN, UNITED ARAB EMIRATES

Project Overview

Analysis 1: Photovoltaic Panels

- Goals and method
- System design
- Energy produced
- Cost and schedule
- Payback
- Conclusion

Analysis 2: Solar Shading

- Goals and method
- System design
- Energy saved
- Cost comparison
- Payback comparison
- Conclusion

Analysis 3: Prefabrication

- Goals and method
- Truland Industries
- Hospital Example
- Items prefabricated
- Prefabrication savings
- Conclusion

Analyses Conclusions and Recommendations

Acknowledgments

Project Location: In the heart of Ajman City, United Arab Emirates

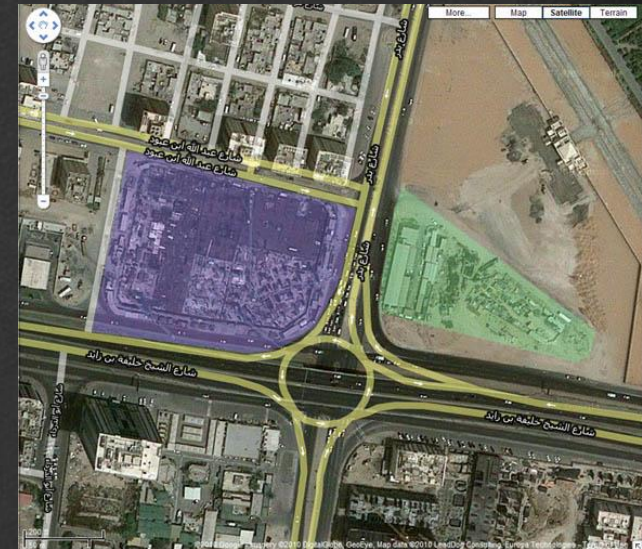
Size: 2,300,000 Square Feet

Project Components: 3-story Shopping Mall,
22-story Residential Tower
26-story Office Tower
5-Story Parking

Construction Schedule: June / 9 / 2008
November / 8 / 2011

Project Cost Estimate: \$164.4 Million

Delivery Method: Design-Build



Google maps view of the project location

Project Layout:

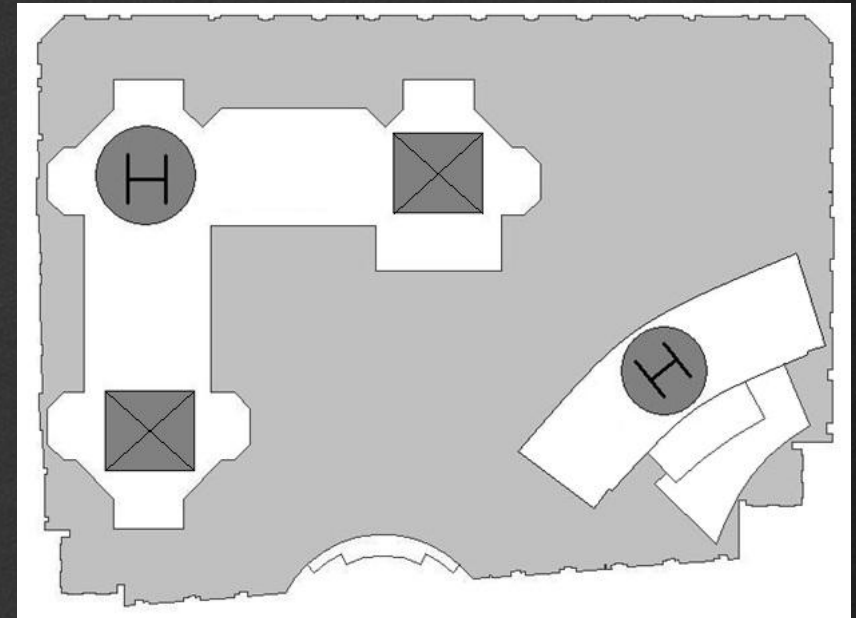
3 floors Underground Parking

3 floors Shopping Mall

2 floors Upper level Parking

20 floors + Penthouse Residential Tower

26 floors Office Tower



Project Layout

Analysis 1: Photovoltaic Panels

Analyze the feasibility of a PV solar system by:

- Finding the best products
- Researching sunlight nature in the UAE
- Determining the energy produced by the system
- Calculating the cost of the system
- Determining the payback period



Product:

Yingli's YL225P-29b Solar Panel
Each panel is 17.6 sq ft

System Components:

- (240) x 225W Panels
- (15) x 2,900W Inverters
- Wiring and Mounting Equipment

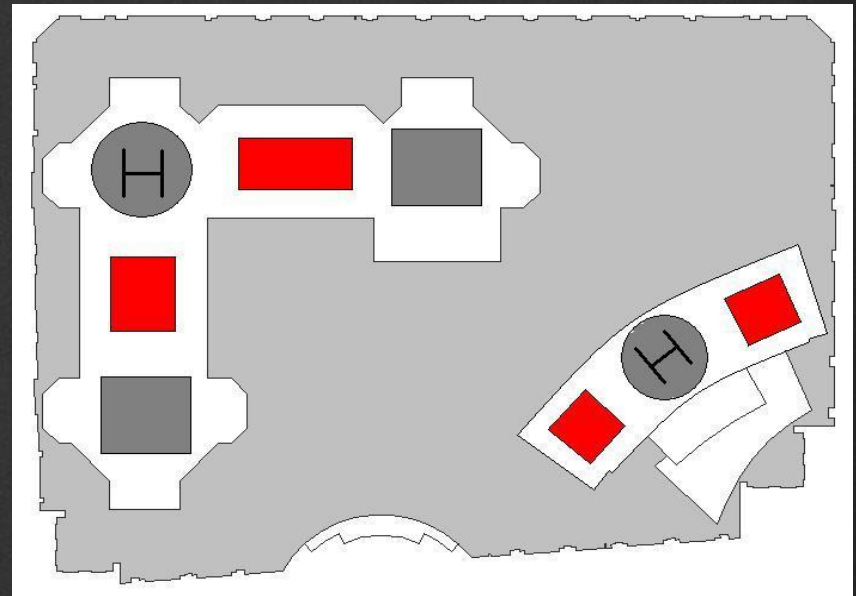


Location of the panels:

Solar panels are divided into 4 groups
They will be installed on the tower's rooftops

Panels Orientation:

Solar panels will be facing south
They will be tilted 30° south



Panels' locations shown in red

Energy Production:

- Solar radiation average in the UAE is 6.3 KWh/m² per day
- (240) 225W panels will produce about 122,500 KWh per year
- The energy tied to the grid is less than 122,500 KWh since the energy goes through inverters before it is connected to the system
- The total energy tied to the system is about 98,600 KWh per year

Quantity and Period of use	Power Output
1 Panel	225 W
240 Panels system	54 KW
System x 6.3 kWh/m ² per day	340.2 KWh
System x 30 days	10,206 KWh
System x 12 months	122,472 KWh

PV Panels Power Output

Quantity and Period of use	Power Output
1 inverter	2,900 W
15 inverters	43.5 kW
System x 6.3 kWh/m ² per day	274 kWh
System x 30 days	8,222 kWh
System x 12 months	98,658 kWh

Solar System Power Output

System Cost:

- The PV solar system total cost is \$233,295
- There are no government incentives or any kind of credit for green and energy efficient products in the UAE

Schedule:

- The schedule of the project will not be affected by this addition
- Installing the system will be done by a specialized crew and will not interfere with the original project plan

Description	Cost
12 x (20 Yingli solar panels pallet)	\$124,200
15 x PVI 3000-208V inverter	\$28,095
Mounting equipment at (\$0.50 per Watt)	\$27,000
Installation cost at (\$1 per Watt)	\$54,000
Total cost of the system	\$233,295

System Payback:

- Discounted Payback Method was used to determine the payback period for the solar system
- 4% is the interest rate assumed for the calculation
- The system will payback it's cost after 75 years

Number of Years	Value of Savings at Specific Single Year	Total Value of Savings up to the Specific Year
1	\$9,486.346	\$9,486.346
5	\$8,108.968	\$43,920.79
10	\$6,664.981	\$80,020.48
25	\$3,700.827	\$154,124.3
50	\$1,388.243	\$211,938.9
75	\$520.7531	\$233,626.2
100	\$195.3432	\$241,761.4

Conclusion:

- The UAE is one of the best locations for PV systems
- The system can produce good amount of energy, but a payback period of 75 years is not acceptable

Analysis 2: Solar Shading

Determine the effectiveness of solar louvers by:

- Finding the best products
- Finding the best location on the project
- Calculating windows' heat gain
- Calculating energy savings
- Calculating cost and payback
- Comparing the 2 products



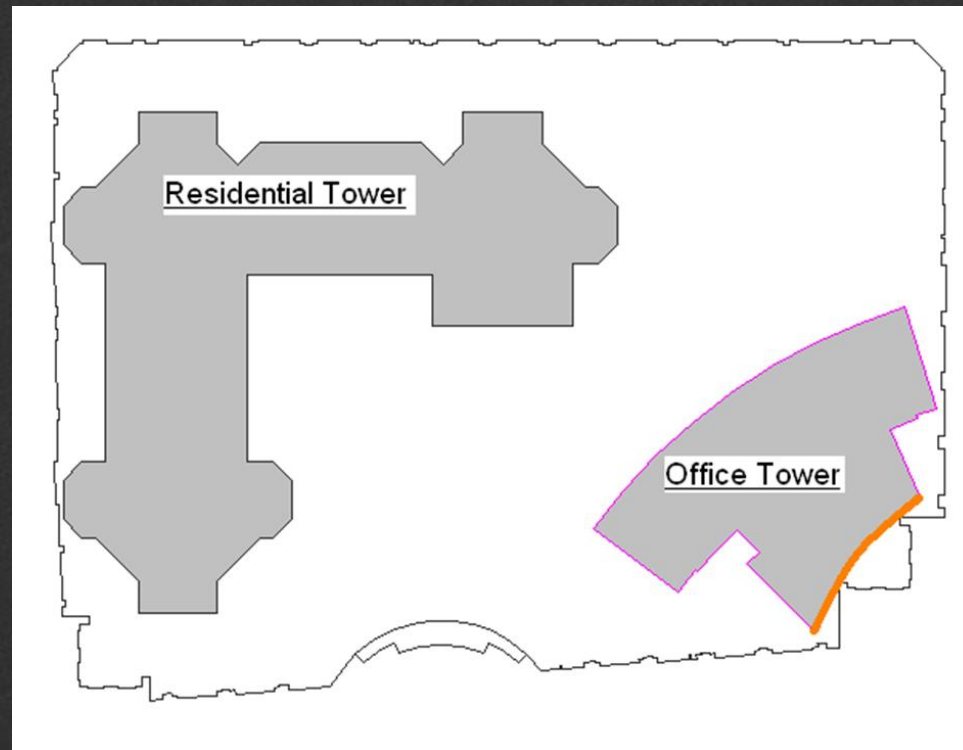
Product:

Nysan Aerofoil Aluminum Louvers
18 inch VS. 24 inch louvers



Location of Louvers:

- Office tower is all glass, so the louvers are most effective on it
- UAE is in the northern hemisphere, so the sun is always south
- Best location of louvers: Office tower south façade



Window Heat Gain:

There is 17,108 ft² of glass windows on the south façade where the louvers are to be installed

Those windows gain
3.4 Billion BTUs per year

Month	Solar Heat Gain (BTUs)
January	472,659,824
February	361,594,688
March	266,508,428
April	145,503,540
May	122,082,688
June	119,294,084
July	123,092,060
August	153,219,248
September	269,143,056
October	414,543,948
November	471,017,456
December	495,516,112
Total BTUs per year	3,414,175,132

SOLAR SHADING

MURUR MIXED-USE COMPLEX HAMAD ALRAHMANI

Energy Savings:

Month	BTUs Saved by 24 in Louvers	BTUs Saved by 18 in Louvers
January	56,719,179	40,412,415
February	84,613,157	60,169,356
March	135,919,298	101,539,711
April	123,387,002	100,397,442
May	122,082,688	122,082,688
June	119,294,084	119,294,084
July	123,092,060	123,092,060
August	153,219,248	138,479,556
September	151,796,683	127,735,294
October	143,846,750	100,278,181
November	69,710,583	49,268,425
December	50,542,643	36,073,573
Total	1,334,223,375	1,118,822,785

Energy Savings:

- The 24 inch louver system saves about 1.33 Billion BTUs per year

1.33 Billion BTUs = 391,000 KWh = \$35,183 per year

- The 18 inch louver system saves about 1.12 Billion BTUs per year

1.12 Billion BTUs = 328,000 KWh = \$29,503 per year

Cost Comparison:

- Total cost of 24 inch system:
\$292,328

- Total cost of 18 inch system:
\$128,310



SOLAR SHADING

MURUR MIXED-USE COMPLEX HAMAD ALRAHMANI

Payback Comparison:

- The 24 inch system needs 10 years to payback the initial cost

- The 18 inch system needs less than 5 years to payback

Number of Years	Value of Savings at each Single Year	Total Value of Savings up to the Specific Year
1	35,183	35,183
2	33829.81	69,013
3	32528.66	101,541
4	31277.56	132,819
5	30074.58	162,894
6	28917.86	191,811
7	27805.64	219,617
8	26736.19	246,353
9	25707.87	272,061
10	24719.11	296,780
11	23768.37	320,549
12	22854.21	343,403
13	21975.2	365,378
14	21130	386,508
15	20317.31	406,825

Number of Years	Value of Savings at each Single Year	Total Value of Savings up to the Specific Year
1	29503	29503
2	28368.27	57871.27
3	27277.18	85148.45
4	26228.06	111376.5
5	25219.29	136595.8
6	24249.32	160845.1
7	23316.65	184161.8
8	22419.86	206581.6
9	21557.55	228139.2
10	20728.42	248867.6
11	19931.17	268798.8
12	19164.59	287963.3
13	18427.49	306390.8
14	17718.74	324109.6
15	17037.25	341146.8

Conclusion:

- Solar shading saves a huge amount of energy
- The two different sizes have small differences in energy savings, but big differences in cost
- 18 inch system saves less energy, but the payback is less than 5 years

Analysis 3: Prefabrication

Determining prefabrication benefits through:

- Researching existing projects
- Collecting information from industry experts
- Applying prefabrication on Murur Project
- Calculating prefabrication savings



Truland Industries:

Information by Ian Foster:

On a recent job:

- Receptacle boxes were prefabricated and accounted for only 5,000 hours which is 50% of the original time to complete the job
- Also resulted in an overall labor saving of about 3%

Typically:

- typical labor savings for the specific activity being prefabricated is 20%-30%
- time saving can reach up to 50% of the original duration of the single activity that has been prefabricated

Hospital Prefabrication Example:

Prefabrication process started midway through design development

- 178 patient rooms
- 120 corridor utility racks

18 workers in prefab shop, zero injuries

2 months off the schedule

2% off the cost



Bench-height work

Items to be Prefabricated:

- Receptacle boxes, fully assembled and ready to install
- Raceways and conduit racks for electrical wiring that are preassembled in one piece
- Ducts for ventilation, exactly measured so they can fit with no on-site adjustments
- Plumbing pipes, designed to fit perfectly taking ducts and raceways into consideration
- Conduits that are cut exactly as needed
- Pre-mounted electrical panels



Prefabrication Savings:

25% time saving is being used for calculations

This prefabrication process can save the job 100 days

Less workers are needed to finish the same job, faster

Dollar value savings including revenue can reach over \$3.8 Million

Description	Savings
Time (25% of total time of 400 days)	100 days
Labor (50 x 50 days x 8hr/day x \$8/hr)	\$160,000
Cleaning and waste management (30% of \$309,362 from GC estimate)	\$92,808
More recycling material	No \$ value
Expected revenue (100 days assuming 8% per year revenue)	3,594,520
Total	\$3,847,328

Conclusion:

- Prefabrication process must start at the beginning of a project
- Many items can be prefabricated
- 100 days can be cut off the schedule of Murur Complex
- Over \$3.8 million can be saved on Murur project by prefabrication

Analyses Conclusions and Recommendations

Photovoltaic Panels:

- Payback period of 75 years is unreasonable
- Wait until cost is less, or until there are government incentives

Solar Shading:

- 18 inch louvers are the best choice
- With less than 5 years to payback the cost, this is a must do

Prefabrication:

- Benefits include:
-cost reduction, -less labor, -schedule cut, -waste management
- With expected dollar value savings of \$3.8 million, prefabrication is a must do

ACKNOWLEDGMENTS

MURUR MIXED-USE COMPLEX HAMAD ALRAHMANI

Ali Moosa and Sons:

Especially to:

Engr. Ahmad Ali Moosa
Engr. Mohammed Saleh



Penn State AE department:

Especially to:

Professor Moses Ling
Professor M. Kevin Parfitt
Professor John Messner
Professor William Bahnfleth



My Friends:

Especially to:

Jaafar Al Aidaroos
Mohamed Alali
Samir Al Azri

Ian Foster (Truland Industries)

Everyone who had a part in helping me achieve what I did...

Thank you