

Introduction

This homework studies the power distribution of Dar Al Baydaa, the building Abdul Kader resides in. It is a 10-floor residential building with 19 apartments. Floors 1-9 contain two apartments each (North and South) and Floor 10 contains being one apartment. Dar Al Baydaa apartment is used as the reference apartment in our homework, and it is supplied by three-phase power. The system is traced from both EDL and the neighborhood electricity supplier, Hashem Electric Distribution, a local supplier in Mar Elias, Beirut to the apartment distribution boards. The feeder calculations use the same apartment demand obtained in Abdul Kader's Assessment 2 (16.196 kW). We will assume PF of 0.85 as per advised in class. Cable selection follows the Week 3 lecture table for 60°C rubber-insulated three-phase cables. A 40°C ambient correction factor of 0.87 is used. Cable lengths were not measured, so a numerical voltage-drop value is not invented.

Part 1 - Observed Building and Supply Arrangement

- Building: 10 floors and 19 apartments, Floors 1-9 have two apartments each, while Floor 10 has one apartment.
- Reference apartment is a three-phase supply. The home panel shows approximately 220 V, 219 V and 220 V phase-to-neutral and a Schneider four-pole C63 main MCB.
- EDL building-side three-phase meters, contactors and protective devices were photographed in the building's basement. The apartment EDL meter is three-phase, and the elevator has a separate EDL branch too.
- Neighborhood supplier Hashem Electric Distribution in Mar Elias, Beirut. The supplier panel for Dar Al Baydaa is three-phase and includes a 150 A three-pole MCCB.
- Regarding the elevator, a separate three-phase supplier meter was observed, and the EDL side has a breaker marked 30 A. The elevator motor rating itself was not available, so its load is not calculated, as it is an old elevator and we don't want to assume anything wrong.



Figure 1 - Abdul Kader's Apartment Distribution Board

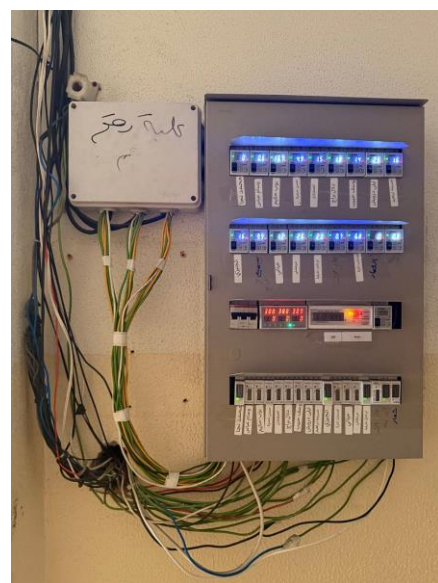


Figure 2 - Hashem supplier panelboard serving Dar Al Baydaa (Abdul Kader's Building in Mar Elias, Beirut)

Part 2 - Single-Line Diagram & Building Riser Diagram

The SLD below follows the equipment that was visible in our photographs. Either EDL or the neighborhood supplier feeds the building distribution system, then the building riser feeds the apartments and the elevator as separate branches.

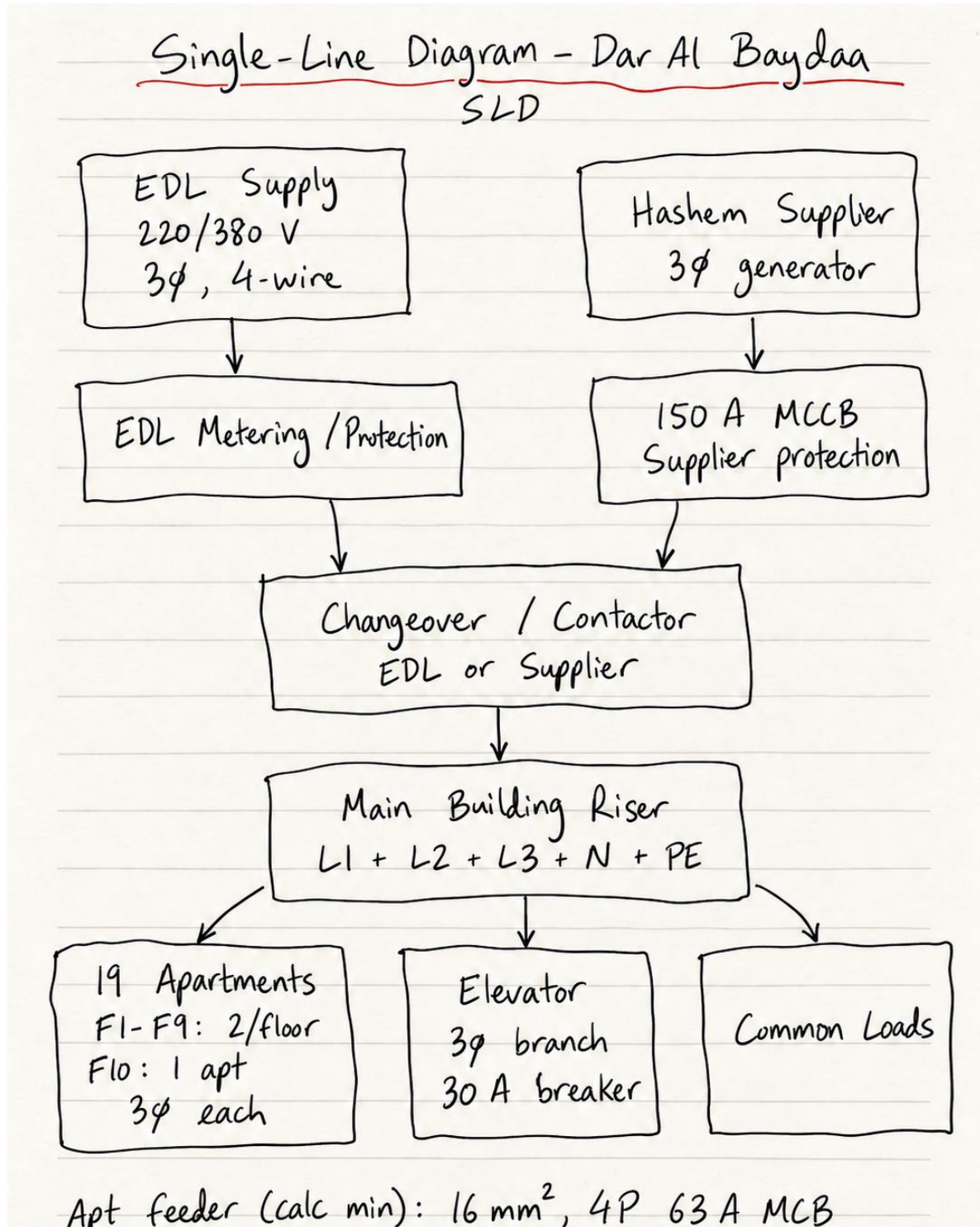


Figure 3 - Simplified SLD for the Building's Power Distribution

Because every apartment in this case is three-phase, the apartment branches are shown as 3-phase feeders rather than assigning individual apartments to only one phase.

Sadly in Lebanon, Earthing is not used, but we decided to add it for a better and cleaner presentation.

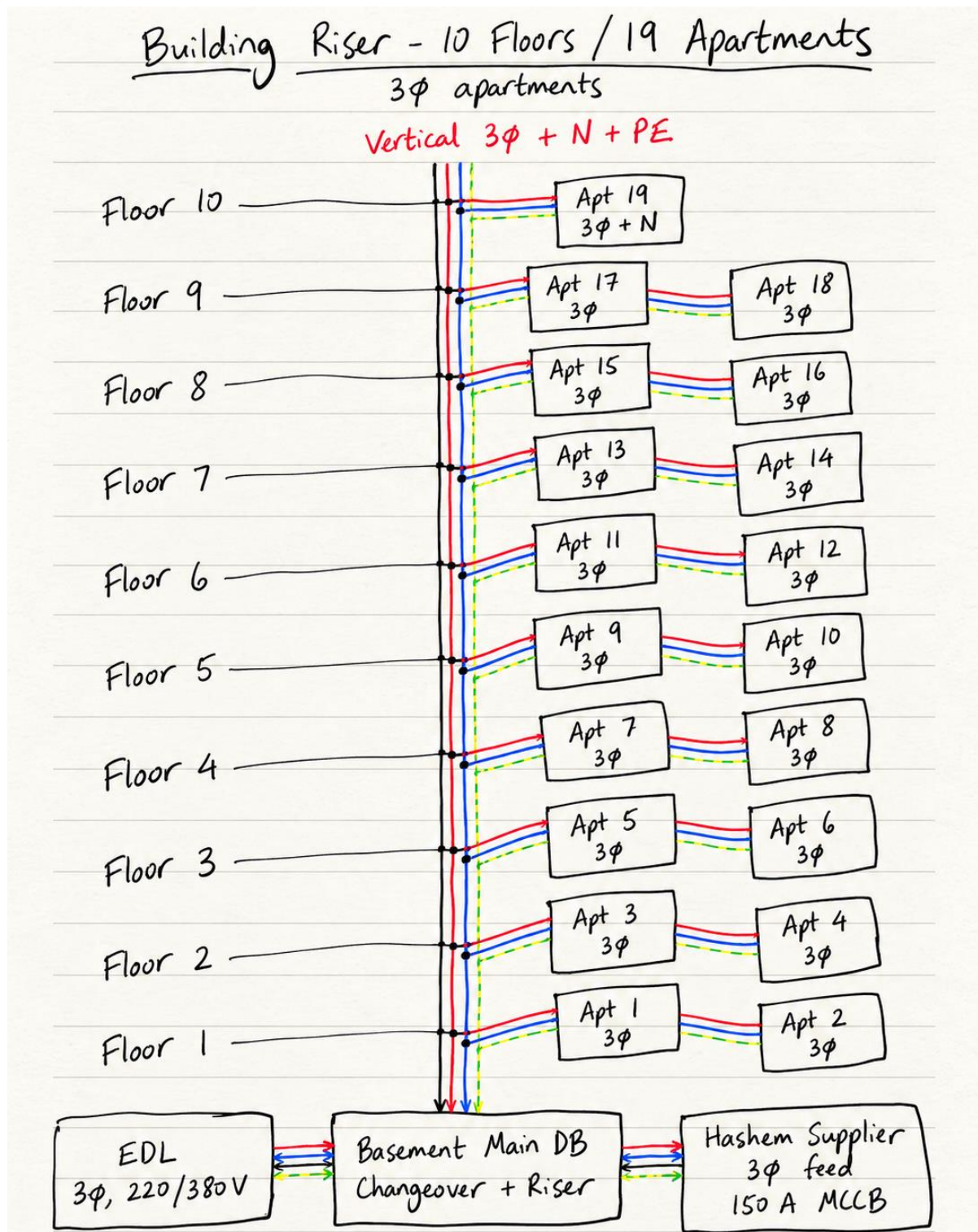


Figure 4 - 10-floor riser arrangement for 19 apartments

Part 3 - Cable and Circuit Breaker Sizing, Supplier Feeder, Elevator and Voltage Drop

3.1 Reference Apartment Feeder Load of one apartment: 16.196 kW

→ $P_{apt} = 16.196 \text{ kW}$ (calculated in assessment 2)
assuming $PF = 0.85$

→ $S_{apt} = \frac{16.196 \times 10^3}{0.85} = 19.05 \text{ kVA}$

$$I_{load} = \frac{19.05 \times 10^3}{\sqrt{3} \times 380} = 28.95 \text{ A}$$

→ Adding spare 25% capacity

$$I_b = 1.25 \times 28.95 = 36.19 \text{ A}$$

- At 40°C ambient temp., $C_a = 0.87$
- Assuming no grouping for our feeder, $C_g = 1$

→ $I_{z, req} = \frac{36.19}{0.87 \times 1} = 41.59 \text{ A}$

now $6 \text{ mm}^2 \rightarrow 34 \text{ A}$
 $10 \text{ mm}^2 \rightarrow 47 \text{ A}$ (table at 60°C 3- ϕ)

The minimal cable sizing in our case is 10 mm^2 but as per seen on apartment's panelboard,

a C63 4-pole MCB Main MCB was used

$$I_b \leq I_n \leq I_2$$

$\swarrow$
36.19 A

$\searrow$
63 A

our I_2 would
be either 63 A

3.2 Main Building Feeder

60°C
3-Ø { 16mm² → 63 A
25mm² → 83 A

Assuming similarity between all 19 apartments

$$K_d = 0.53 \quad \text{for 15-19 apartments}$$

$$P_{19 \text{ apts}} = 19 \times 16.196 = 307.724 \text{ kW}$$

• after diversity

$$P_{\text{diversity}} = 0.53 \times 307.724 = 163.094 \text{ kW}$$

• adding 15% margin design

$$P_{\text{building}} = 163.094 \times 1.15 = 187.558 \text{ kW}$$

$$S_{\text{building}} = \frac{187.558}{0.85} = 220.656 \text{ kVA}$$

$$I_b = \frac{220.656 \times 10^3}{\sqrt{3} \times 380} = 335.25 \text{ A}$$

$$I_{z, \text{eq}} = \frac{335.25}{0.87 \times 1} = 385.35 \text{ A}$$

from table $240 \text{ mm}^2 \rightarrow 343 \text{ A}$

(60° C)
3-φ

$300 \text{ mm}^2 \rightarrow 394 \text{ A}$

$$I_b \leq I_n \leq I_z$$

$$\downarrow$$

$$335.25 \text{ A}$$

$$\hookrightarrow 394 \text{ A}$$

choose a 400 MCCB

and adjust in anywhere

between 340 to 390 A

~~~~~ We will set  $I_n = 340 \text{ A}$

### 3.3 Neighborhood Supplier Feeder

The Hashem Electric Distribution board feeding Dar Al-Baydaa has a three-pole MCCB marked 150 A. If the feeder is checked against this observed 150 A protective device using the same 40°C assumption.

then  $I_{2,14} = \frac{150}{0.87} = 172.41 \text{ A}$

or  $60^\circ\text{C}, 3-\phi$

$70 \text{ mm}^2 \rightarrow 158 \text{ A}$

$95 \text{ mm}^2 \rightarrow 192 \text{ A}$

$I_0 \leq I_n \leq I_2$

$150 \text{ A MCCB} \rightarrow 192 \text{ A}$

$95 \text{ mm}^2 \text{ cable } 3-\phi$

### 3.4 Elevator

The elevator is treated as a separate three-phase load. A 30 A breaker was observed on the EDL side, while the building distribution panel contains a dedicated elevator entry labeled “Elevator 285” without 285 being specified for what, this is included in the pictures attached below.

### 3.5 Voltage Drop

No cable-run lengths were measured. Therefore we can’t calculate the exact voltage drop and if it exceeds limits or not ( $\leq 5\%$  by default).

### 3.6 Final Results Summary Table

| Level                    | Design Current         | Derating Used   | Calculated Cable         | Protection                           |
|--------------------------|------------------------|-----------------|--------------------------|--------------------------------------|
| Apartment                | 36.19 A                | $0.87 \times 1$ | 16 mm**2, 60°C, 3-phase  | 4-Pole 63 A MCB (calculated)         |
| Building Main            | 335.25 A               | $0.87 \times 1$ | 300 mm**2, 60°C, 3-phase | 400 A MCCB frame, Ir approx. = 340 A |
| Hashem Electric Supplier | 150 A (observed) limit | $0.87 \times 1$ | 95 mm**2, 60°C, 3-phase  | 150 A 3-Phase MCCB observed          |

## Part 4 - Site Photographs and Equipment Observations

The following photographs are used only for information that can be read or identified directly. Hidden cable sizes and internal wiring are not assumed.



**Figure 5 - Apartment Panel Board: Schneider four-pole C63; phase readings = 220/219/220 V (3-Phase)**



**Figure 6 - Hashem three-phase MCCB, handle marked 150 A.  
Fun Fact: NOTICE 3-PHASE COLORS OF INDIA's National Code, as per in the slides.**



**Figure 7 - Separate EDL elevator breaker, handle marked 30 A**



**Figure 8 - Three-phase EDL meter serving Abdul Kader's apartment**

## (Bonus) | Source of EDL Power and Neighborhood Supplier

The Lebanon distribution sequence used in the lecture notes is: generation at 11 or 22 kV, stepped up to 150 or 220 kV for transmission which is SAD, then stepped down through 66/33/11 kV levels, then a neighborhood transformer from 11 kV to about 400 V (Abdul Kader tried so search for the local neighborhood transformer yet couldn't find it nearby). The main LV distribution then supplies consumers at 220/380 V, 50 Hz (Contradiction US where they operate at 60 Hz).

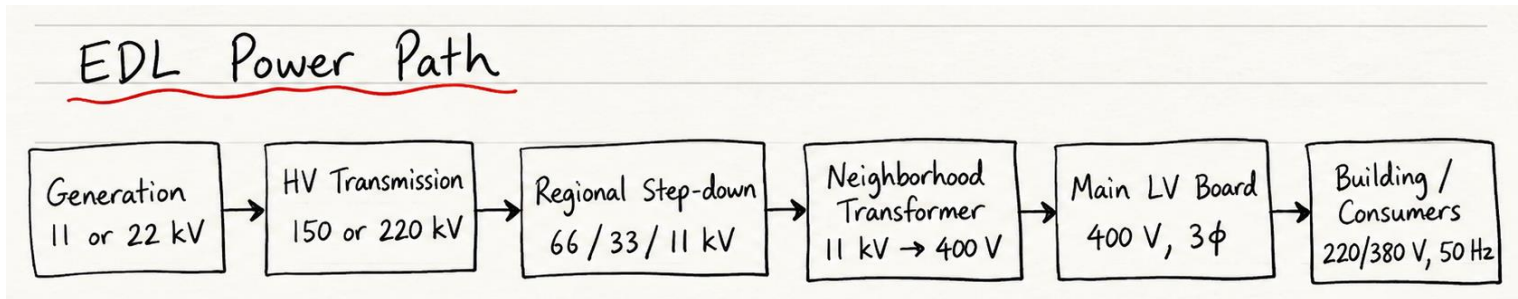


**Figure 9 - EDL source-to-building path from the EECE 475 lecture material**

The alternative source was traced to Hashem Electric Distribution in Mar Elias, where we photographed generator units and three-phase distribution equipment. Please note that the EDL neighborhood transformer (nowhere to be found nearby) and its LV distribution board (each apartment had his special EDL board in the basement, we took a photo of Abdul Kader's one) are not provided in the supplied photographs.



**Figure 10 - Hashem Electric Distribution Generator Unit**

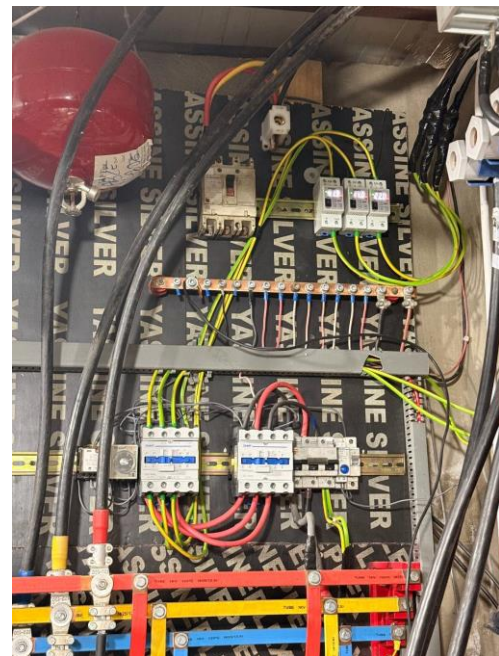


**Figure 11 - Hashem three-phase switching and protection equipment**

## Appendix - Additional Evidence



Figure 12 - Supplier Elevator meter: 3-phase, 4-wire, 3 x 230/400 V

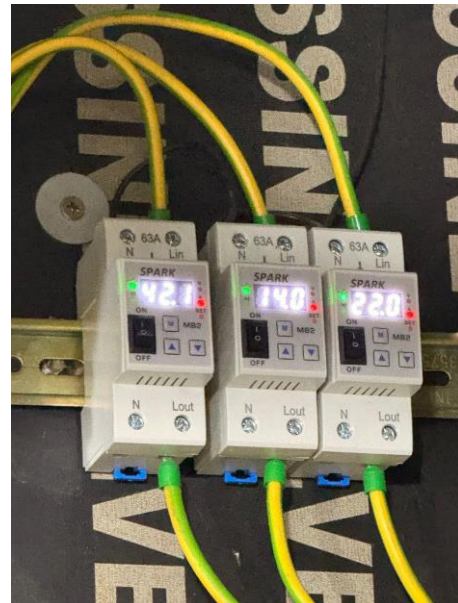


Figure 13 - Three 63 A monitoring at supplier distribution



Figure 14 - EDL three-phase meter marked 220/380 V, 50 Hz

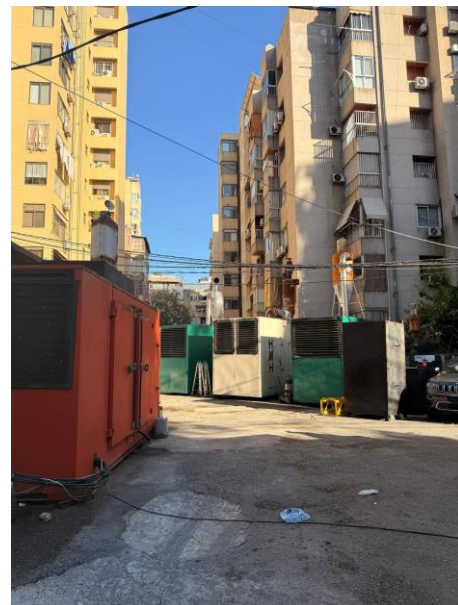


Figure 15 - Generator Area at Hashem Electric Distribution

## References

- **EECE 475 Material** posted on Moodle (Week 2-3-4, including derating and diversity factors, IEC method, adding spare capacity 20-25%, MCB/MCCB ratings and IEC rule  $I_b < I_r = I_z$ ,  $PF = 0.85$  etc...).
- **Abdul Kader El Hakim's Assessment 2** for already calculated apartment demand 16.196 kW
- **EECE The Material's Tables attached at the end of the document below.**
- **Site Photographs taken Sunday September 27th**, including Abdul Kader's apartment, equipment's, building's EDL equipment, and Hashem Electric Distribution's equipment.

| Standard Ampere Ratings |      |      |      |      |
|-------------------------|------|------|------|------|
| 15                      | 20   | 25   | 30   | 35   |
| 40                      | 45   | 50   | 60   | 70   |
| 80                      | 90   | 100  | 110  | 125  |
| 150                     | 175  | 200  | 225  | 250  |
| 300                     | 350  | 400  | 450  | 500  |
| 600                     | 700  | 800  | 1000 | 1200 |
| 1600                    | 2000 | 2500 | 3000 | 4000 |
| 5000                    | 6000 | —    | —    | —    |

## Diversity Factor for distribution switchboards

| Number of circuits                               | Diversity Factor (ks) |
|--------------------------------------------------|-----------------------|
| Assemblies entirely tested 2 and 3               | 0.9                   |
| 4 and 5                                          | 0.8                   |
| 6 to 9                                           | 0.7                   |
| 10 and more                                      | 0.6                   |
| Assemblies partially tested in every case choose | 1                     |

| Conductor<br>C.S.A. | Current carrying capacity and associated voltage drop           |                  |                                            |        |                                                                 |                  |                                            |        |
|---------------------|-----------------------------------------------------------------|------------------|--------------------------------------------|--------|-----------------------------------------------------------------|------------------|--------------------------------------------|--------|
|                     | 60°C rubber insulated                                           |                  |                                            |        | 90°C rubber insulated <sup>a</sup>                              |                  |                                            |        |
|                     | 1 two-core cable* or 2 single core cables touching <sup>1</sup> |                  | 1 three-core, four-core or five-core cable |        | 1 two-core cable* or 2 single core cables touching <sup>1</sup> |                  | 1 three-core, four-core or five-core cable |        |
|                     | d.c. or single phase a.c.                                       |                  | three phase a.c.                           |        | d.c. or single phase a.c.                                       |                  | three phase a.c.                           |        |
| mm <sup>2</sup>     | A                                                               | mV/A/m           | A                                          | mV/A/m | A                                                               | mV/A/m           | A                                          | mV/A/m |
| 4                   | 30                                                              | 12               | 26                                         | 10     | 42                                                              | 13.2             | 37                                         | 11     |
| 6                   | 39                                                              | 7.8              | 34                                         | 6.7    | 55                                                              | 8.5              | 49                                         | 7.3    |
| 10                  | 51                                                              | 4.6              | 47                                         | 4.0    | 76                                                              | 5.1              | 66                                         | 4.3    |
| 16                  | 73                                                              | 2.9              | 63                                         | 2.5    | 103                                                             | 3.2              | 89                                         | 2.7    |
| 25                  | 97                                                              | 1.8d<br>1.85a    | 83                                         | 1.55   | 136                                                             | 2.03d<br>2.04a   | 119                                        | 1.73   |
| 35                  | 140                                                             | 1.31d<br>1.32a   | 102                                        | 1.15   | 200                                                             | 1.42d<br>1.46a   | 146                                        | 1.23   |
| 50                  | 175                                                             | 0.91d<br>0.93a   | 124                                        | 0.84   | 250                                                             | 1.00d<br>1.02a   | 177                                        | 0.93   |
| 70                  | 216                                                             | 0.64d<br>0.67a   | 158                                        | 0.58   | 310                                                             | 0.71d<br>0.73a   | 225                                        | 0.64   |
| 95                  | 258                                                             | 0.49d<br>0.53a   | 192                                        | 0.44   | 369                                                             | 0.54a<br>0.57d   | 273                                        | 0.49   |
| 120                 | 302                                                             | 0.38d<br>0.43a   | 222                                        | 0.36   | 432                                                             | 0.42d<br>0.46a   | 316                                        | 0.39   |
| 150                 | 347                                                             | 0.31d<br>0.36a   | 255                                        | 0.30   | 497                                                             | 0.34d<br>0.39a   | 363                                        | 0.32   |
| 185                 | 394                                                             | 0.25d<br>0.32a   | 291                                        | 0.26   | 564                                                             | 0.27d<br>0.33a   | 414                                        | 0.27   |
| 240                 | 471                                                             | 0.19d<br>0.27a   | 343                                        | 0.21   | 673                                                             | 0.21d<br>0.28a   | 487                                        | 0.23   |
| 300                 | 541                                                             | 0.15d<br>0.24a   | 394                                        | 0.185  | 773                                                             | 0.167d<br>0.25a  | 560                                        | 0.195  |
| 400                 | 644                                                             | 0.115d<br>0.21a  | -                                          | -      | 885                                                             | 0.127d<br>0.22a  | -                                          | -      |
| 500                 | 738                                                             | 0.090d<br>0.20a  | -                                          | -      | 1017                                                            | 0.100d<br>0.20a  | -                                          | -      |
| 630                 | 861                                                             | 0.068d<br>0.185a | -                                          | -      | 1190                                                            | 0.074d<br>0.190a | -                                          | -      |

CABLE TYPE:  
INSTALLATION  
CONDITIONS:

MULTICORE  
IN TRAYS, RACKS, CLEATS OR OTHER SUPPORTS IN AIR

| 1        | 2                                 | 3                                                                                     | 4                | 5    | 6    | 7    | 8    | 9    | 10   |
|----------|-----------------------------------|---------------------------------------------------------------------------------------|------------------|------|------|------|------|------|------|
| Item No. | Installation                      | Number of tiers or rows of cable supports                                             | Derating factors |      |      |      |      |      |      |
|          |                                   |                                                                                       | Number of cables |      |      |      |      |      |      |
|          |                                   |                                                                                       | 1                | 2    | 3    | 4    | 6    | 9    |      |
| 1        | Unperforated trays                |  | 1                | 0.97 | 0.85 | 0.78 | 0.75 | 0.71 | 0.68 |
| 2        |                                   |                                                                                       | 2                | 0.97 | 0.84 | 0.76 | 0.73 | 0.68 | 0.63 |
| 3        |                                   |                                                                                       | 3                | 0.97 | 0.83 | 0.75 | 0.72 | 0.66 | 0.61 |
| 4        |                                   |  | 1                | 0.97 | 0.96 | 0.94 | 0.93 | 0.90 | —    |
| 5        |                                   |                                                                                       | 2                | 0.97 | 0.95 | 0.92 | 0.90 | 0.86 | —    |
| 6        |                                   |                                                                                       | 3                | 0.97 | 0.94 | 0.91 | 0.89 | 0.84 | —    |
| 7        | Perforated trays                  |  | 1                | 1.00 | 0.88 | 0.82 | 0.78 | 0.76 | 0.73 |
| 8        |                                   |                                                                                       | 2                | 1.00 | 0.87 | 0.80 | 0.76 | 0.73 | 0.68 |
| 9        |                                   |                                                                                       | 3                | 1.00 | 0.86 | 0.79 | 0.75 | 0.71 | 0.66 |
| 10       |                                   |  | 1                | 1.00 | 1.00 | 0.98 | 0.95 | 0.91 | —    |
| 11       |                                   |                                                                                       | 2                | 1.00 | 0.99 | 0.96 | 0.92 | 0.87 | —    |
| 12       |                                   |                                                                                       | 3                | 1.00 | 0.98 | 0.95 | 0.91 | 0.85 | —    |
| 13       | Ladder supports, racks and cleats |  | 1                | 1.00 | 0.87 | 0.82 | 0.80 | 0.79 | 0.78 |
| 14       |                                   |                                                                                       | 2                | 1.00 | 0.86 | 0.80 | 0.78 | 0.76 | 0.73 |
| 15       |                                   |                                                                                       | 3                | 1.00 | 0.85 | 0.79 | 0.76 | 0.73 | 0.70 |
| 16       |                                   |  | 1                | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | —    |
| 17       |                                   |                                                                                       | 2                | 1.00 | 0.99 | 0.98 | 0.97 | 0.96 | —    |
| 18       |                                   |                                                                                       | 3                | 1.00 | 0.98 | 0.97 | 0.96 | 0.93 | —    |
| 19       | Vertical perforated trays         |  | 1                | 1.00 | 0.88 | 0.82 | 0.77 | 0.73 | 0.72 |
| 20       |                                   |                                                                                       | 2                | 1.00 | 0.88 | 0.81 | 0.76 | 0.72 | 0.70 |
| 21       |                                   |                                                                                       | 1                | 1.00 | 0.91 | 0.89 | 0.88 | 0.87 | —    |