ATTACHMENT

Attachment 7 - 1 Standards for 66/20 kV Distribution Substations

1. Scope of Application

The Standards for 66/20 kV Distribution Substations shall be applied to planning and design for construction of new substations and reinforcement/ augmentation of the existing substations.

2. Voltage and Type

The primary and secondary voltages of 66/20kV distribution substations are as follows:

Table A7.1-1 Nominal Voltage of Substation

Primary Voltage	(kV)	66
Secondary Voltage	(kV)	20

The transformers shall be of three-phase type with on-load tap changer.

3. Location of Substation

Location of substation shall be selected so that the substation would be located in an appropriate site from long term view points, taking into account the following items:

(1) Location convenient for connection with the existing/ planned 20 kV network and in or close to the supply area
(2) Easiness in aligning incoming 66 kV and outgoing 20 kV lines
(3) Selection of type of a substation with due considerations of regional environment, and securing the required space or volume for the substation
(4) Influence of various kinds of disaster, e.g. flood, landslide, fire, dust contamination, land subsidence, etc.
(5) Effective use of public land or PEDEEE's own premises
(6) Convenience in operation and maintenance
(7) Easiness in transportation of large and heavy cargoes
(8) Easiness in construction of foundations for heavy equipment
(9) Costs for land acquisition, land preparation, timing of land acquisition and anticipated difficulties
(10) Coordination with regional government

4. Unit Capacity and Number of Units of Main Transformers

The unit capacity and number of units of main transformers in a substation shall be determined, taking into account economic feasibility, redundancy requirements, system reliability, voltage drop, demand forecast, land acquisition, problems in aligning 66 kV lines, available roads as 20 kV line routes, diversion plan of equipment, etc. The standard unit capacity and number of units for main transformers are shown in Table A7.1-2.

It is preferable to design the transformer capacity so that the remaining units can supply peak load power even when any one transformer is out of service. In Japan, a distribution substation is usually provided with three transformers of capacity to supply peak power with two units.

For a new small substation, one unit installation of transformer can be adopted if the required system reliability can be maintained even under outage of the transformer by switching over of all interrupted loads to other lines. Also one unit installation may be allowed to minimize construction cost if influence due to loss of unit is not so serious.

Table A7.1-2 Area-wise Unit Capacity and Quantity of Transformers

Location of Substation	Scale
High density load area	30 MVA x 2 units, 3 units
Urban area	20 MVA x 2 units, 3 units
Rural area	10 MVA x 1 unit, 2 units

5. Ratings of Circuit Breakers

The rated normal current of circuit breaker shall be commensurate with the short time overloading capacity of the connected transmission lines or transformers.

Table A7.1-3 Rated Normal Current of Circuit Breaker

Voltage (kV)	Standard Rated Normal Current (A)
66	800, 1,250, 1,600, 2,000, 2,500
20	400, 630, 800, 1,250

The rated short-circuit breaking current of circuit breaker shall be selected from the standard ratings based on the results of fault calculation under various circuit conditions with the help of computer software. In calculation, future system extension shall be taken into account.

The standard rated short-circuit breaking current for each voltage level is shown in following Table.

Table A7.1-4 Rated Short-Circuit Breaking Current of Circuit Breaker

Voltage Level (kV)	Rated Short-Circuit Breaking Current (kA)
66	20, 25, 31.5
20	25

6. Capacitor Banks

(1) In principle, 20 kV static capacitors for 66/20 kV substations are installed to control the 66 kV system voltage. If the 66 kV side voltage of the 230/66 kV side voltage is kept at the desired level, static capacitors are required at substations up to which voltage drop in line is excessive. Required total capacity and unit capacity of capacitors and locations of installation are to be determined referring to the results of power flow calculation.

(2) The rated voltage of capacitors shall be 20 kV and capacitors shall be connected to the 20 kV bus.

(3) One bank of static capacitors shall consist of a number of small capacitor units provided with load switches capable to switch on and off the units automatically under the on-line conditions. A circuit breaker set shall be provided with bank.

(4) The standard capacity of capacitor bank is shown in the following Table A7.1-5.

The momentary variation of bus voltage due to switching in and out of capacitor unit shall not exceed 2%. Such voltage variation shall be checked during the power flow calculation.

Table A7.1-5 Unit Capacity of Static Capacitor Bank

Type	Voltage (kV)	Capacity (MVA)
Static Capacitor Bank	20	5, 10

7. Number of Outgoing Feeders

The number of 20 kV outgoing feeders per unit capacity of transformer shall, in principle, comply with the following Table.

Table A7.1-6 Maximum Number of Outgoing Feeders per one Transformer

Unit Capacity of Transformer (MVA)	Maximum Number of Outgoing Feeders
30	10
20	8
10	6

8. Basic Idea of Substation Connection

The connection of substation shall be designed to maximize functions of the substation in overall power system, taking into consideration of the followings:

(1) Daily operation and maintenance shall be performed safely with proper manners.

(2) The connection shall be as simple as possible without affecting the maximum performance of substation equipment and their combination.

(3) In case that faults occurred in a substation, influence of the faults shall be limited to the minimum extent and necessary switching operations to shift loads to other substations shall be able to be performed quickly without trouble.

(4) The operation of power system shall not be heavily affected by separation of any one substation facility.

(5) Considerations must be paid to easiness in future reinforcement and/or augmentation when necessary.

(6) Design must be economically feasible.

9. Connection of 66 kV Incoming Lines

A 66 kV incoming line shall be connected to the 66 kV busbar through a circuit breaker on each circuit. However, in case that a 66 kV line is a part of a unit network system, the 66 kV line can be connected to the main transformer directly without 66kV circuit breaker.

10. Busbar arrangement

(1) Busbar system

The busbar system for a 66/20kV substations shall be selected from Table A7.1-7 and 8, taking into account of coordination with related 66 kV and 20 kV networks in view of supply reliability, operation and maintenance, and other factors.

For important substations with transformers of 30 MVA and above, the double busbar system may be adopted to improve supply reliability. The 20 kV busbars of transformers shall not be operated in parallel with other transformer under normal condition. The tie circuit breaker shall be closed only when one transformer is out of service or any necessity arises.

Table A7.1-7 66 kV Busbar Arrangement

Busbar System	Application
Double Busbar system with One Bus-tie Coupler	In principle this busbar system shall be applied to major 66/20 kV substations and large substations.
Single Busbar System	For substations where number of incoming lines is limited and chance of network switching operation is not much.
Without Busbar	In case of unit network system with only one underground line connected to the main transformer.

Table A7.1-8 20 kV Busbar Arrangement

Busbar System	Application
Single Busbar System	This busbar system is in principle applied and a tie circuit breaker or a load-break switch is to be provided to connect with busbar of another transformer.

(2) Rated Current Capacity

The standard rated current capacity (continuous) of busbar is shown on Table A7.1-9.

Table A7.1-9 Rated Current of Substation Bus

Voltage (kV)	Standard Rated Current (A)
66	1,600
20	1,600

Note: The standard rated current of busbar is decided from the estimated maximum current under the normal operation as well as under fault and/or unit outage conditions as follows:

(1) Single busbar : Outage of one 66 kV line or one unit of transformer.

(2) Double busbar : Outage of one 66 kV line or one unit of transformer when one busbar is out of service.

11. Switching Apparatus for Transformer

When a transformer is to be cut off due to faults on the related busbars or transformer itself or for the purpose of maintenance, the transformer shall be provided with circuit breakers (or load break switches) on both the primary and secondary sides.

12. Connection of Secondary Outgoing Feeders

The secondary outgoing lines shall be connected to the secondary busbar through a circuit breaker for each circuit.

13. Type of Substations

Type of substation shall be selected from the following types, either one classified type or a combination of types, with due consideration of regional and surrounding environment, in order to obtain the high overall performance of the substation.

(1) Outdoor type[1]

The standard type of substation shall be in principle of outdoor type.

(2) Indoor type[2]

(a) In case that the indoor type substation is economically justified compared with the outdoor type because of very high price for land acquisition.

(b) Where it is required to employ the indoor type substation in view of protection from noise, fire protection, environment, etc.

(c) Where salt/dust contamination is severe or the case substation is located close to the sea coast and protection of equipment from the pollution by salt is difficult if the outdoor type is adopted.

(d) Where the construction of outdoor type substation is restricted by laws or regulations of the Government.

(3) Underground type[3]

(a) Where a substation is constructed in the basement of a building or a park, etc. due to difficulty in land acquisition in the highly populated area or urban area.

(b) Where price of land is extremely high and it is economically advantageous to adopt an underground substation for effective utilization of the ground.

14. Countermeasures for Disasters

(1) Salt/Dust Pollution

When a substation is constructed in an area affected by salt/dust contamination, appropriate countermeasures shall be taken in the design based on the level of pollution.

(2) Lightning

For the protection of substation equipment from lightning, appropriate measures shall be taken in design of substation taking into account required network reliability and site-specific conditions.

(3) Flood

When a substation is required in an area affected by flood or high wave, appropriate measures shall be taken to prevent damages to equipment to the minimum and to restore operation as early as possible.

(4) Fire

For fire protection of substation, appropriate fighting measures shall be taken to protect personnel and equipment from fire or explosion and, at the worst, to localize the fire within a limited area.

(5) Earthquake

Equipment and building of substations shall be so designed as to withstand the maximum earthquake ever experienced.

15. Fire Protection of Transformers

To prevent an accident of main transformer from spreading of fire to adjacent sets, necessary measures should be taken to prevent spreading of fire and outflow of leaked oil. For fire fighting, water is sprayed for outdoor transformers and chemical fire extinguishers are provided for indoor transformers.

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[1] Outdoor type substation means a substation whose all major equipment e.g. main transformers, switchgear equipment, etc. are arranged in open air.

[2] Indoor type substation means a substation that all major equipment of substation, e.g. main transformers, switchgear equipment, etc. are installed in a building.

[3] Underground type means that major equipment of substation are installed underground.

16. Countermeasures for Environment

(1) Noise

When a substation is to be newly constructed or expanded, necessary measures shall be planned to limit noise within the prescribed noise level in laws or regulations.

(2) Vibration

When a substation is to be constructed or expanded, necessary measures shall be planned to limit vibration level within the standard value prescribed in the anti-vibration laws or regulations.

(3) Harmony with Environment

When a substation is to be constructed or expanded, special attentions shall be paid to protection of natural environment of surrounding areas by planting trees, constructing regulation ponds, etc. and preserving living environment e.g. sunshine, beauty, radio interference, etc. and a harmony with the regional community.

Attachment 7 - 2 Standards for 66 kV Transmission Lines

1. Scope of Application

These Standards for 66 kV Transmission Lines shall be applied to planning and design for construction of 66 kV transmission lines.

2. Type and Voltage

The following two types of 66 kV transmission lines will be employed as the case may require:

- Overhead transmission lines with bare conductors
- Underground cable lines

The standard type of transmission line shall, in principle, be the overhead transmission line with cheaper cost. Underground cable lines shall be employed in the following cases:

(1) The construction of overhead line is not applicable due to restrictions by Laws and/or Regulations and difficulties in land availability, land acquisition along the route, public objections, etc.

(2) When the underground cable line is considered more advantageous taking into account coordination with regional environment and/or economic aspect.

3. Route Selection

In planning transmission lines, the width and number of routes should be examined in view of the effective use of public land and PEDEEE's land, introduction of new technology, etc. Further, the plan should be fully coordinated with regional and road development plans scheduled by the central and regional governments in order to establish the effective formation of infrastructure facilities.

The route of 66 kV transmission overhead line shall be selected in due consideration of the following:

(1) Justification of coordination with future plans of transmission network and substations
(2) Effective use of public land and PEDEEE's land
(3) Coordination with the regional environment
(4) Aesthetic considerations to natural scenery, national parks, etc.
(5) Various disasters, e.g. flood, dust contamination, fire, land slide, etc.
(6) Minimum influence to inhabitants, relocation of houses, etc.
(7) Difficulties and safety in construction and maintenance of lines
(8) Saving of construction cost and maintenance cost
(9) Reduction of transmission losses
(10) Effective use of the existing cable culverts, multi-purpose tunnels, etc. (for underground lines)
(11) Influence to the transmission capacity caused by applied method of cable installation (for underground cable lines)

4. Overhead Transmission Lines

4.1 Supports and Number of Circuits

(1) Supports for 66 kV overhead transmission lines shall, in principle, be of self-supporting broad-based latticed steel construction. The standard number of circuit to be supported on one support shall be one or two.

(2) Application of various types of special structure for alignment along wide roads, from aesthetic considerations, etc. shall be examined when required.

(3) In case that the two-circuit transmission line needs to be initially operated with single circuit construction from the economic view point, towers shall be so designed as to safely support one circuit of conductors strung on one side for the time being.

(4) In view of the future growth of demand, difficulty in acquiring additional land, regional environment and requirements for redundancy of transmission circuits, towers having more than two circuits are considered preferable in many cases. Four-circuit towers can also be employed if they are technically and economically feasible taking into account the reliability, construction, and operation and maintenance, etc.

4.2 Construction of Supports

The construction of supports other than latticed steel towers can be selected in due consideration of safety during construction and operation and maintenance, as well as aesthetic view points and coordination with regional environment.

The height of supports shall be so determined as to maintain necessary ground clearance of conductors defined based on type of land and land use.

Future modification of once-erected line construction may be required for the purposes of increasing transmission capacity, improving public security, and/or any other reason. In such a case, special considerations shall be paid to the design of supports and ground clearance for erection of larger size conductors, replacement with special conductors, upgrading of voltage level, etc.

4.3 Selection of Conductors

(1) The standard type of conductors for 66 kV overhead transmission line shall be, in principle, "Aluminum Conductor Steel Reinforced (ACSR)". However, in consideration of dust contamination, climatic conditions and increase of transmission capacity, special type of conductors other than ACSR may be applicable. All Aluminum Alloy Conductors (AAAC) are now widely applied in Europe mainly to large transmission lines.

(2) The standard size of conductor shall be selected from the following Table A7.2-1.

Table A7.2-1 Standard Size of Conductor

Voltage (kV)	Type	Size of Conductor
66	ACSR	240/40

Use of larger size conductors shall be reviewed in view of future requirement for a larger transmission capacity. For determination, a wide range economic studies covering land acquisition problem, construction cost, maintenance cost, transmission losses (kW and kWh), etc. will be required from long term considerations. The selection of two sizes, around 400 and 600 mm^2, or one size of around 500 to 550 mm^2 is considered appropriate. (The ESSP Study recommended one size of 400 or 550 mm^2).

The allowable continuous current, short-time current and short-circuit current of the conductors shall be not worked out.

4.4 Phase Arrangement and Transposition

(1) Phase Arrangement

For the two-circuit towers, the phase arrangement of conductors on the both circuits shall be the same or in reverse phase arrangement. The same arrangement means that the conductor phases of both circuits are aligned same on the right and left in a vertical plane (R-S-T order on both sides). The reverse phase arrangement means the conductor phases of both circuits are alinged in the reverse order (if R-S-T arrangement is applied on one side, T-S-R arrangement on the other side).

(2) Transposition

In principle, the conductor transposition is not required for a relatively short 66 kV transmission line.

4.5 Alignment and Size of Overhead Earthwires

One overhead earthwire made of galvanized steel wire of 50 mm^2 in sectional area shall be installed above the conductors for the lightning protection with a shielding angle of not more than 30 degrees.

4.6 Others

In planning and designing overhead transmission lines, due considerations shall be paid to the following points:

(1) Radio interference
(2) Electromagnetic induction to communication lines
(3) Electrostatic induction to human being
(4) Safety measures to the public
(5) Coordination with the natural environment and aesthetic considerations
(6) Considerations to air traffic

5. Underground Cable Lines

5.1 Type of Cables

(1) The standard type of cables is as shown in the following Table A7.2-2:

Table A7.2-2 Standard Type of Cables

Voltage (kV)	Type	Core
66	Cross-linked Polyethylene (XLPE) insulated Polyvinyl chloride sheathed cable (CV)	Single or Triplex

(2) The standard sizes of the cables are shown in the following Table A7.2-3.

Table A7.2-3 Standard Size of Cables

Voltage (kV)	Type	Size (mm^2)	Core
66	CV	Cu 300, 400, 500, 625	Single or Triplex

The size of cables shall be decided taking into account the following:

(a) The size of cables shall be decided with due consideration to future increase of requirement for transmission capacity, construction cost, maintenance cost, transmission losses (kW and kWh), and reduction of transmission capacity due to the method of laying many cables together, cable routes, etc. on a long term basis.

(b) The size of cables shall be sufficient to carry the maximum load current and short-circuit current in the cables.

(c) The allowable maximum temperatures of cables shall be as shown in Table A7.2-4:

Table A7.2-4 Allowable Maximum Temperatures of Cables

Type of Cable	Voltage (kV)	Allowable Maximum Temperature (°C)		
		Continuous	Short-time	Short-circuit
CV	66	90	105	230

Note: The short-time maximum temperature means the temperature necessary to carry short-time current under this temperature for the total period of 3,000 hours through the cable life with frequency of not exceeding 120 hours in a year.

The short-circuit maximum temperature means the maximum temperature that power cables can reach after carrying the short-circuit current for two seconds.

5.2 Methods of Installation

Power cables shall be installed in the following ways:

(1) Direct Burying in the ground

Direct burying is the standard installation method of underground power cables. Power cables are buried directly in the ground and protected by sand and concrete cover plates above the cables.

(2) Laying in Conduits

At the section crossing a main road or other similar places where heavy vehicles pass on the route, power cables shall be installed in protecting conduits, steel pipes, PVC pipes, etc. with appropriate number of man-holes for installation and maintenance purpose.

(3) Laying in Ducts

Where a number of power cables are installed along the same route, power cables shall be installed in cable ducts.

Attachment 7 - 3 Standards for 20 kV and 0.4 kV Distribution Facilities

1. Scope of Application

The Standards for 20 kV and 0.4 kV Distribution Facilities shall be applied to planning and design for construction of new distribution facilities and reinforcement/ extension of the existing facilities.

2. Application of Each Type of Distribution System

Criteria for applying the three types of distribution system are mentioned below:

(1) The Overhead Conductor Distribution System is applied generally in the open field area where there are no restrictions to line construction.

(2) The Underground Distribution System is applied in urban areas, where load density is generally high and construction of overhead line is difficult. The criteria are to be determined by each Company with coordination with PEDEEE.

(3) Overhead Cable Distribution System is applied for the following areas:

(a) Areas where the underground distribution system is applied

(b) Areas where the overhead conductor distribution system is not adequate due to lack of clearance between feeder conductors and buildings, trees, etc.

3. Distribution System Facilities

3.1 Supporting Structures for Overhead Line

(1) Application of Supporting Structures

Standard supporting structures for overhead lines are classified as shown in Table A7.3-1:

Priority of use shall be on locally manufactured concrete poles. For concrete poles, manufacture of longer and stronger poles will be preferred to widen scope of use. To improve workability in construction and maintenance, the pole design to enable fixing of step bolts.

Latticed steel pole shall be used in case that the length and/or strength of concrete poles is not sufficient.

Table A7.3-1 Application of Supporting Structures

Supporting structures	Application
Concrete poles	Generally applied (first priority for selection)
Latticed steel poles	Applied to locations where large strength is required (at angle and terminal points)
Wooden poles	Applied to areas where access of heavy machines is difficult (mountainous areas)

(2) Selection of Location of Supporting Structures

Locations of supporting structures should be selected at places where

(a) Easy to access

(b) Soil condition is firm and stable

(c) No troubles are expected in land acquisition

In urban areas, the proper locations for supports will be on the roadway side of sidewalk, or the roadside of roadway, and in rural area in public lands within 20 meters from the road.

(3) Span Length of Supporting Structures

The span length between distribution line supports is to be determined taking into account the followings:

(a) Strength of supporting structures

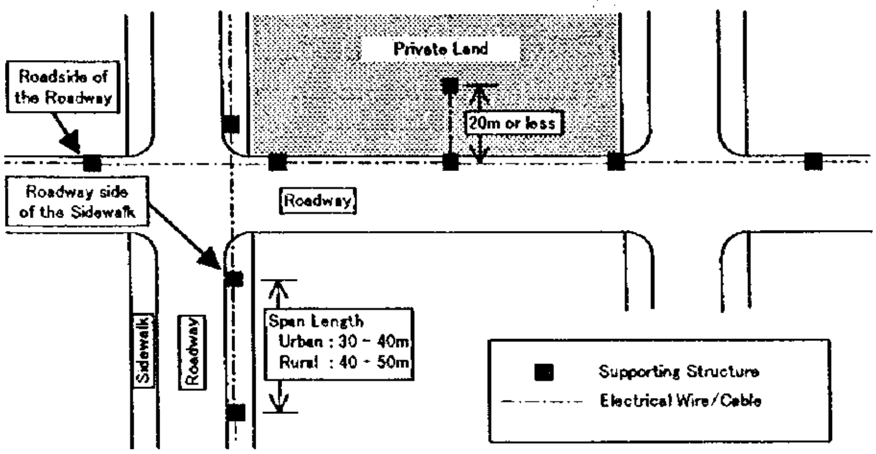
(b) Ground conditions

(c) Load density in the area

It is preferable that the same span length is uniformly applied in one area. The recommended span lengths of the distribution line supports are as follows:

Table A7.3-2 Recommended Span Length

Area	Recommended Span Length
Urban area	30 – 40 m
Rural area	40 – 50 m



Example of Installation Plan of Supporting Structures

(4) Height of Supporting Structures

The height of supporting structures is to be determined taking into account the following factors:

(a) Necessary height of the feeder conductors above the ground can be secured under the laegest sag.

(b) Necessary clearance between the feeder conductors and buildings, other electrical wires or trees can be secured (clearance under maximum sag should be examined).

(c) In undulated area, height of poles shall be adjusted to minimize up and down of the feeder conductors.

The recommended height of the supporting structures is as follows:

Table A7.3-3 Recommended Height of Supporting Structures

Area	Recommended Support Height	
	20 kV (+LV) feeders	LV feeders
Urban area	12 m	10.5 m
Rural area	10.5~12 m	9.15~10.5 m

The recommended minimum pole setting depth is as follows:

Table A7.3-4 Recommended Pole Setting Depth

Pole length	Ground Classifications		
	Solid Rock	Firm Soil	Poor Soil
7 m	1.0 m	1.3 m	1.6 m
8 m	1.0 m	1.4 m	1.6 m
9 m	1.0 m	1.5 m	1.6 m
10 m	1.2 m	1.6 m	1.8 m
11 m	1.2 m	1.7 m	1.8 m
12 m	1.5 m	1.8 m	2.1 m
14 m	1.7 m	2.0 m	3 m

3.2 Electrical Conductors and Cables

(1) Standard Sizes of Electrical Conductors and Cables to be Used

The standard sizes of overhead line conductors and cables to be used for 20 kV and LV feeders are determined taking into account the load density, construction cost of 20/0.4 kV feeders and transformers, conductor resistance and generation cost as given bellow:

Table A7.3-5 Standard Sizes of Conductors and Cables

System		Cond./Cables		Remarks
20 kV	Overhead conductor	AS	120mm²	
		AS	70mm²	
		AS	35mm²	
	Overhead cable	Al	185mm²	Applied to
		Al	120mm²	- Multiple phase stringing
		Al	70mm²	- Routes with small clearance
	Underground cable	Cu	185mm²	
		Al	185mm²	
		Al	120mm²	
		Al	70mm²	
LV	Overhead conductor	Al	120mm²	
		Al	70mm²	
		Al	35mm²	
	Overhead cable	Al	120mm²	Applied to routes with small clearance
		Al	70mm²	
	Underground cable	Cu	185mm²	
		Cu	120mm²	
		Cu	70mm²	
		Cu	35mm²	

(2) Selection of Sizes of Overhead Conductors and Cables

Sizes of overhead conductors and cables of distribution feeders should be selected taking into account amount of present load, forecasted load, short-circuit current, current capacity of conductors and cables, voltage drop, power loss, mechanical strength, etc. Too many sizes shall not be used for branch feeders. The generally applied sectional areas are tabulated bellow:

Table A7.3-6 Sizes of Overhead Conductors and Cables

(1) 20 kV feeders

Feeder	Overhead Cond.	Overhead Cables	Underground Cables
Main feeder	AS 120mm²	Al 185mm²	Al 185mm²
Branch feeder	AS 35mm² or larger	Al 70mm² or larger	Al 70mm² or larger

(2) LV feeders

Feeder	Overhead Cond.	Overhead Cables	Underground Cables
Main feeder	AS 120mm²	Al 120mm²	Cu 120mm²
Other	Al 35mm² or larger	Al 70mm² or larger	Cu 35mm² or larger

The size of feeder conductors shall be same all through the entire length of feeder from the starting point to the end so as to permit flexible operation of the system.

The sectional area of cables for the underground section of an overhead feeder (for instance the first section between substation cubicle and the first pole) is to be determined taking into account the current capacity under the installed condition. The combination of overhead feeder conductors and underground cables in the same section (including that for the first section of a feeder) is given in the following table:

Table A7.3-7 Conductor Sizes and Cable Sizes

	Overhead Conductors		Underground Cables	
20 kV	AS	120mm²	Al	185mm²
	AS	70mm²	Al	185mm²
	AS	35mm²	Al	70mm²
0.4 kV	Al	120mm²	Cu	185mm²
	Al	70mm²	Cu	120mm²
	Al	35mm²	Cu	70mm²

(3) Sag of Overhead Conductors

Conductor sag is to be determined taking into account the allowable conductor tension, strength of the supporting structures, wind load on conductors, etc. However, the conductor sag corresponding to 1 to 2% of span length between supporting structures is appropriate.

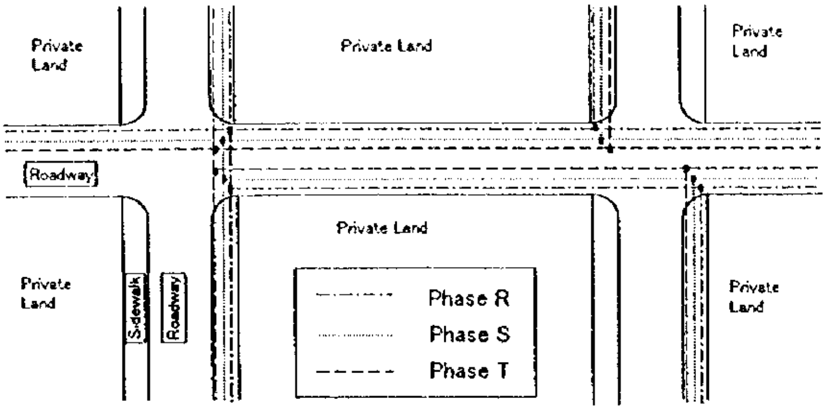
(4) Phase Arrangement of Conductors

To avoid troubles in the switching operations and construction works, the phase arrangement of conductors should be determined commonly to all lines based on a certain principle.

The recommended phase arrangement of conductors is as follows:

Table A7.3-8 Phase Conductor Arrangement

Conductor Arrangement	Phase – R	Phase - S	Phase – T
Horizontal type	House side	Center	Road side
Vertical type	Top	Center	Bottom



Horizontal Conductor Arrangement

(5) Installation of Underground Cables

The route of underground cables is to be determined taking into account the following factors:

(a) Easiness in construction works.

(b) Causing no troubles in construction and maintenance works in future.

(c) To keep the same offset distance from the roadside on the same street.

In principle, the route of underground cables is to be selected on the sidewalk of road. In case that there is no sidewalk on the road, the cable route is aligned along the roadside of roadway.

The installation depth of 20 kV underground cables shall be 1,200mm, and the installation method shall follow the standard practice regarding soil coverage, bundle spacing, etc. Cables are to be installed in anti-stress plastic pipes or other protection materials, i.e. ducts or tunnels. Indication films are to be buried 300mm above the cable ducts to indicate that electrical cables are buried under the films.

In case that new cables are to be buried by excavating ditches, extra pipes should also be buried as required to meet future needs for laying additional cable(s) or replacing the existing cable(s).

The lower part of rising cables toward the top of pole from the underground is to be protected with iron pipes. The iron pipes shall be provided to 2.5 meters above the ground surface.

(6) Protection of LV Conductors and Cables

To protect LV feeders, fuses are to be installed in a main LV branch box at the transformer. The following fuses are generally provided to protect overhead conductors and cables:

Table A7.3-9 Fuses for LV Line

Feeder	Conductors		Fuse (A)	Remarks
Overhead	Al	120mm^2	400A	
Conductor	Al	70 mm^2	250A	
	Al	35mm^2	160A	
Overhead	Al	120mm^2	250A	
Cable	Al	70mm^2	160A	

Underground Cable	Cu	185mm²	400A	In deciding the fuse capacity, installation condition of the cables should also be taken into account.
	Cu	120mm²	315A	
	Cu	70mm²	250A	
	Cu	35mm²	160A	

3.3 Distribution Transformers

(1) Application of Distribution Transformers

The 20/0.4 kV distribution transformers shall be of three-phase construction, and their standard capacities are:

50 kVA, 100 kVA, 200 kVA, 400 kVA, 630 kVA, 1,000 kVA, 1,600 kVA, 2,500 kVA

(2) Selection of Unit Capacity

Before deciding the unit capacity of new transformers, the supply area of new transformers is to be determined taking into account the followings:

(a) Supply area of new transformers shall not overlap with that of other transformers supplied from other feeders.

(b) Supply area of each transformer must be independent.

(c) Voltage drop restriction should be satisfied at any part of the supply area.

The capacity of new transformers should be determined taking into account the expected demand growth of the area, however the smallest capacity that satisfies present demand in the area is generally applied. Recommended capacities of the transformers for public use are as follows:

Table A7.3-10 Recommended Unit Capacities of Distribution Transformers

Area	Recommended Unit Capacity
Urban area	100 kVA*, 200 kVA*, 400 kVA**, 630 kVA**
Rural area	50 kVA*, 100 kVA*, 200 kVA*, 400 kVA**

* : Pole mounted installation will be applied.

** : Method of installation (pole or ground mounted) should be examined for each unit.

(3) Percentage Loading

The maximum loading is 100%, and over loading shall not be allowed so as to impair life of transformers. The transformers tend to be used long time till their breakdown without regular maintenance.

(4) Location

Transformers shall be located in or close to the load center of the area. In deciding the final location to install transformer, the following conditions should also be examined:

(a) Easy to access and replacement works.

(b) To be separated from other buildings or trees with enough clearance

(c) For pole mounted type, pole assembly shall not be complicated.

(d) Ground mounted type structures shall be constructed so as to avoid troubles with public.

(5) **Protection Devices**

A disconnector and a cutout fuse are to be installed on the primary side of a transformer. A circuit breaker provided with overcurrent protection is to be installed on the secondary circuit of transformer. The capacities of cutout fuse and circuit breaker corresponding to transformer capacities are as tabulated bellow:

Table A7.3-11 Capacities of Cutout Fuses and Circuit Breakers

Capacity of Transformer	Cutout Fuse	Circuit Breaker
50 kVA	6 A	80A
100 kVA	10 A	160 A
200 kVA	16 A	300 A
400 kVA	25 A	630 A
630 kVA	40 A	1,000 A
1,000 kVA	45 A	1,600 A
1,600 kVA	50 A	2,500 A
2,500 kVA	80 A	3,800 A

To protect transformers in the overhead system from lightning strokes, lightning arresters are to be provided. The installation point of lightning arresters is on the drop line to the primary side of the transformer from a 20 kV feeder.

3.4 Switching Apparatus

(1) Installation of Switching Apparatus

The following three types of 20 kV switching apparatus are to be provided on feeder circuits for distribution system operation as mentioned below:

(1) Section switch

Section switches are used to sectionalize 20 kV feeders and these are normally closed. Usually, one feeder is divided into four sections; the first section from a substation doesn't feed any load, and the rest of the three sections feed approximately one third of the feeder's load. It is recommended to try to interconnect each of these three sections to other feeders.

(2) Interconnection switch

Interconnection switches are used to interconnect with another feeder, and they are normally open.

(3) Service entrance switch

Service entrance switches are installed on the branch feeders to consumers.

(2) Properties of Switching Apparatus

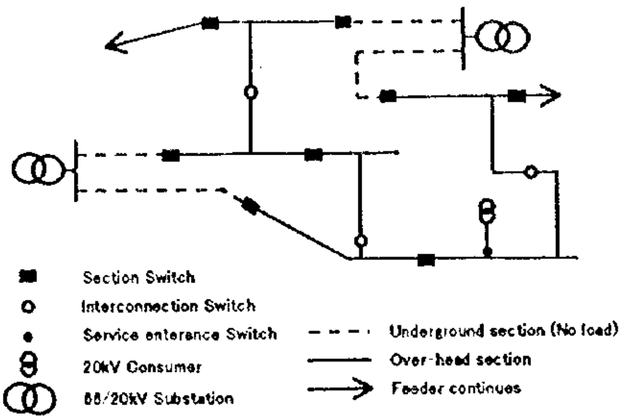
20 kV load break switches that can break load current are recommended to be used as section and interconnection switches. These switches should be located at places where switching operations and replacement works can be performed easily.

Introduction of automatic switches for automatic supply restoration is to be examined taking into account the followings:

(a) Scale of black out

(b) Difficulty in restoration works

(c) Past fault records



Example of Switching Apparatus Installed on 20 kV Feeders

3.5 Service Wires/Cables

(1) Application of Service Wires/Cables

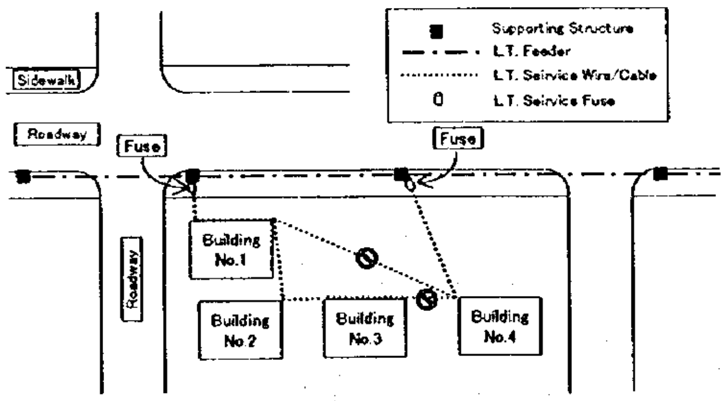
One building must be supplied through only a set of LV service wires/cables. The length of service wires/cables should be as short as possible. The number of buildings supplied by a set of service wires/cables shall not exceed three. The balance of phase currents after connection of a number of single-phase loads shall be examined. The wires/cables of the smallest sectional area shall be used from the following considerations:

(a) Capacity of the wire/cable is sufficient to carry peak load current(s)

(b) Voltage drop criterion is satisfied

(2) Protection

A fuse is to be installed for each service wire/cable. Installation points of fuses are at the LV feeder side terminals of service wires/cables.



Example of LV Service Wire Installation

Attachment 7 - 4 Standards for Planning Distribution Facilities

It is important to establish Standards for Planning Distribution Facilities in the documented style, which should contain items mentioned below. The standards shall be utilized as bases for planning the distribution network and facilities in systematic and economic manners. The standards will present the requisites of facilities needed for planning that are adopted to form existing facilities, conditions of social environment, service needs and renovation of technology, etc. In this report, the JICA study team presents a draft idea of standards for planning on the bases of site survey. The standards are hoped to be adequate for planning of distribution systems in PEDEEE.

1. Objects

The Standards for Planning Distribution Facilities shall be applied to the planning works of distribution facilities in PEDEEE.

2. Offices in Charge of Planning Works

The planning works will be conducted in the following offices. The contents of planning works should be reviewed well through discussions before finalizing.

Table A7.4-1 Offices in Charge of the Planning Works

Type of Facilities	Offices in Charge of the Planning Works
Planning for construction of 66 kV lines, installation of 66/20 kV substations and transformers	The Central office of PEDEEE (Planning & Statistics Department)
Planning for construction of 20 kV lines	Each distribution company office under PEDEEE (Studies & Construction Department)
Planning for installation of 20/0.4 kV transformers and construction of low voltage feeders	

3. Voltage Classes

The standard voltage classes of the overall distribution network are as given below:

66 kV、 20 kV、 400-230V (380-220V) Δ

Δ: 400-230V at the 20/0.4 kV transformer secondary and 380-220V at the consumer ends.

4. Voltage Regulation

The permissible limits of voltage drop in distribution lines under normal operation should be as listed in Table A7.4-2, and voltages at the consumer supply points should be within the ranges listed in Table A7.4-3.

Table A7.4-2 Permissible Limits of Voltage Drop

Voltage Level	Limits of Voltage Drop (%)
20 kV	6 %
Low voltage	8 %

Larger voltage drop shall be granted under single contingency faults.

Table A7.4-3 Voltage at Consumer Supply Points

Voltage Level	Voltage at Supply Point
20 kV	20 kV ± 6%
Low voltage	220V or 380V ± 5%

Voltages at the primary and secondary buses of a 66/20 kV substation should always be maintained close to the target voltages shown in Table A7.4-4. The target shall be set on a high side during the peak time and on a low side during the off-peak time.

Table A7.4-4 Target Operating Voltage of 66/20 kV Substation

Voltage at primary buses	66 kV
Voltage at secondary buses	20 kV

5. System Reliability

The system reliability should be reviewed taking into account scale, duration and frequency of the faults that are considered to possibly occur under normal operation. The chance of supply interruption can be statistically analyzed using these factors. The distribution network should be planned so as to satisfy the system reliability shown in Table A7.4-5. The normal power supply should be able to be restored after short supply interruption due to a single facility fault (loss of one line component either line section, transformer, etc.) by utilizing circuit redundancy or circuit changing over operations. The estimated peak values in a year should be assumed as loads for system planning.

Table A7.4-5 System Reliability

Type of Systems	Reliability to be Satisfied
66 kV systems	In case of a fault of one line element, electricity supply shall be able to be restored by circuit switching operations.
66/20 kV substations	In case of a fault of one transformer, loading of the remaining transformers shall not exceed 110% of rated capacities after switching operations of 20 kV feeders.
20 kV systems	In case of a fault of one line element, electricity supply shall be able to be restored by switching operations except for the fault section of line.
20/0.4 kV transformers	Loading of a transformer shall not exceed the rated capacity. New consumers shall not be connected to a transformer that is loaded exceeding 80% of rated capacity.

6. Fault Current Level

Fault current in the distribution network should be kept within the values listed in Table A7.4-6.

Table A7.4-6 Maximum Fault Current

Voltage Level	Fault Current Level
66 kV	25, 31.5 kA
20 kV	25 kA

7. Electricity Systems

Electricity systems in the distribution networks should be as given in Table 7.4-7. For the purpose of earth fault detection, the 20 kV system should be earthed at the substation through earthing transformers (zigzag connection).

Table 7.4-7 Electricity Systems

66 kV system	3 phases 3 lines, neutral earthed
20 kV system	3 phases 3 lines, neutral not earthed
Low voltage system	3 phase 4 lines, neutral earthed

8. Concepts for Design of Network Configuration

The distribution network should be designed based on the concepts shown in Table A7.4-8.

Table A7.4-8 Normal Concepts for Design of Network Configuration

System	Concepts for Design of Network Configuration
66 kV system	Each 66/20 kV substation should be provided with at least two 66 kV service lines.
66/20 kV substation	Each transformer should be operated independently under normal operation without connection with another transformer on the secondary side. Each bus should be provided with bus couplers for parallel operation with other transformers in case that a fault occurs on one transformer.
20 kV feeder system	20 kV feeder system should normally be configured in the form of multi-divided and multi-connected system, that is provided with a number of section switches adequate for circuit changeover among feeders in case that faults occurred on the feeders.
Low Voltage feeders	Low voltage feeder system should normally be configured in radial form.

9. Capacities of 20 kV Distribution Lines

Capacities of 20 kV lines should be selected taking into account demand density in the area, supply reliability and strength of structures. The normal capacities of main feeders of 20 kV lines should be determined as given in the following table.

Table A7.4-9 Normal Current Capacities of Main 20 kV Feeders

	Overhead System	Underground System
Normal Current Capacities	380 A	320 A

For the overhead system, though the current capacity of the overhead section is 380A the capacity of the system is limited to 320A as the underground cable of Al 185 mm^2 is used for the section between the substation cubicle and the terminal pole of overhead section.

10. Installation of Voltage Regulators

Each kind of voltage regulators should be provided in the distribution network based on the principles as mentioned in Table A7.4-10.

Table A7.4-10 Rule of Adoption of Voltage Regulators

Type of Voltage Regulator	Principle of Installation
On-load tap changer	An on-load tap changer should be installed on each transformer of 66/20 kV substations to regulate 20 kV bus voltage within the normal range. There is a practice to regulate tap changing based on load current to set 20 kV bus voltage high when load increases. /1
Capacitor	20 kV capacitors are required on the secondary buses of 66/20 kV substations to regulate the 66 kV bus voltages within a normal range. 400V capacitors are required on the secondary buses of 20/0.4 kV transformers in case that voltage drop in 20 kV feeders exceeded the control limit. The capacitor installation by large consumers should be promoted.
Step voltage regulator /1	This equipment is usually pole mounted used to raise line voltage at mid-point of a long line with an auto transformer so as to compensate line drop in line.
Shunt reactor /1	Shunt reactors are required on the secondary buses of 66/20 kV substations to regulate bus voltage in case that the substation bus voltage goes up high due to large capacity in the cable system.

/1:Practice currently not currently applied in Syria.

11. Quantity and Unit Capacity of Transformers of 66/20 kV Substations

Quantity and unit capacity of transformers of 66/20kV substations shall be decided in accordance with the Article 4 of Attachment 7-1 "Standards for 66/20kV Distribution Substations".

12. Bus Scheme of a 66/20 kV Substations

Bus scheme of a 66/20 kV substation should be designed based on the principle shown in Table A7.4-11.

Table A7.4-11 Regular Bus Schemes at a 66/20 kV Substation

66 kV bus	Single bus for normal step down substation Double bus with a bus tie for important substation
20 kV bus	Single bus with circuit breakers or section switches separating each section Double bus for special cases

Service lines on the primary sides and secondary sides of transformers should be connected to buses through circuit breakers.

13. Circuit Breakers on 66 and 20 kV Circuits

Circuit breakers should be designed to have the rated fault-interrupting currents shown in Table A7.4-12.

Table A7.4-12 Rated Fault-Interrupting Current

Voltage levels	Rated Fault-Breaking Current
66 kV	25, 31.5 kA
20 kV	25 kA

14. Rated Currents of Switches in 20 kV Feeders

Rated currents of switches should be selected from the standard in coordination with the capacities of lines and transformers.

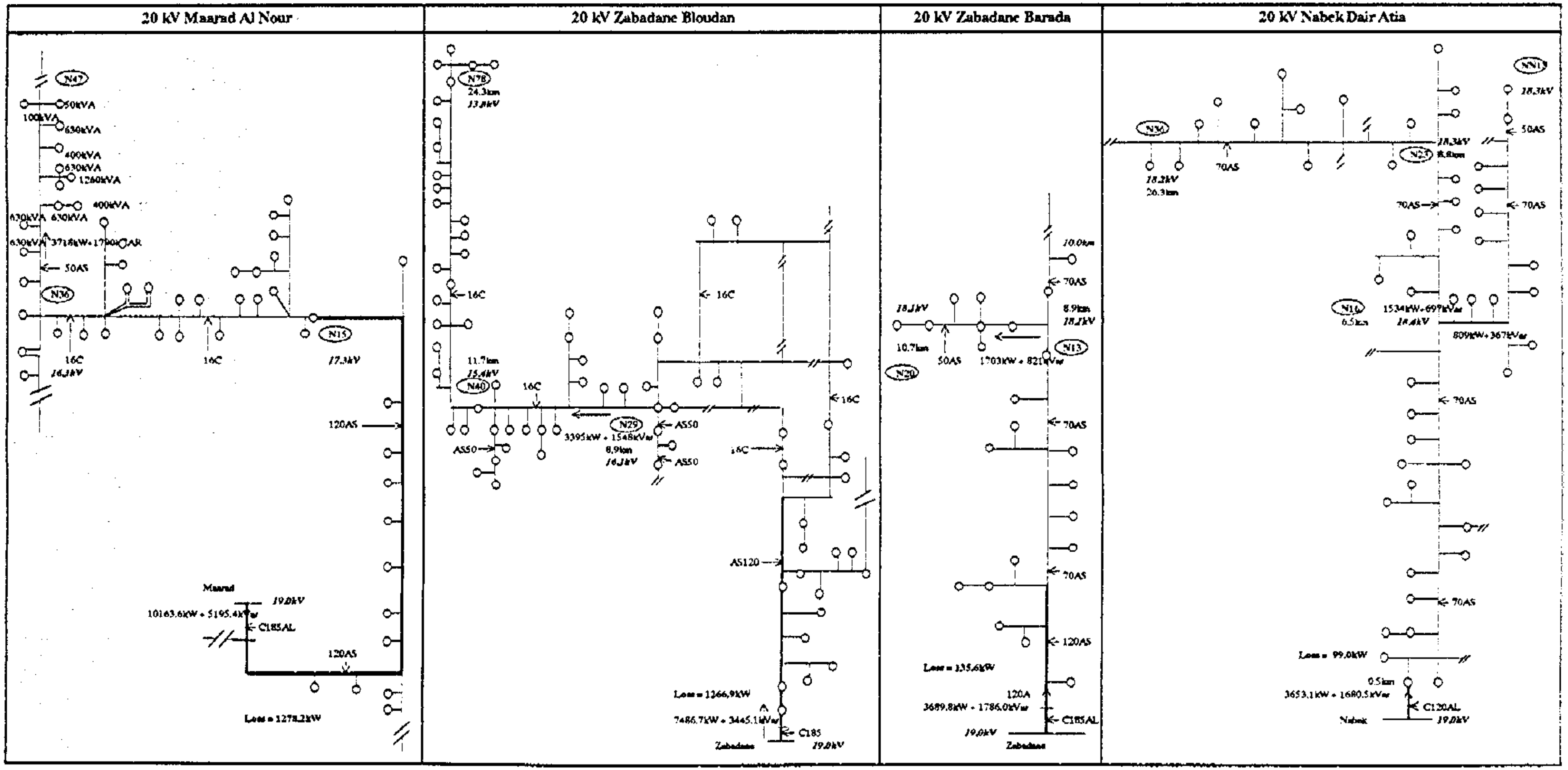
15. Capacities of 20/0.4 kV Transformers

Capacities of 20/0.4 kV transformers should be selected taking into account the demand density, peak loads, growth rate of loads, etc. in the supply area. The normal capacities of 20/0.4 kV transformers are listed on the following table.

Table A7.4-13 Normal Capacities of 20/0.4 kV Transformers

Normal Capacities of 20/0.4 kV Transformers (kVA)
25, 50, 100, 200, 400, 600, 1,000, 1,600, 2,500

Attachment 7-5 Examples of Result of Power Flow Calculation for 20 kV Networks



Attachment 7-6 Example of Result of Power Flow Calculation for 0.4 kV Model Line

1km

219.39 V ∠0deg	183.0 A →	Phase R	0.0 A →	183.65 V ∠6.6deg
219.39 V ∠-120.0deg	150.0 A →	Phase S	0.0 A →	193.27 V ∠-122.7deg
219.39 V ∠120.0deg	117.0 A →	Phase T	0.0 A →	219.68 V ∠122.3deg
0.0 V ∠0.0deg	57.2 A ∠131.8deg →	Neutral Line	0.0 A →	16.89 V ∠-48.2deg

Vb-Vc	380.00 V	Vb-Vc	348.57 V
Vc-Va	380.00 V	Vc-Va	342.02 V
Va-Vb	380.00 V	Va-Vb	340.65 V

(voltage drop ratio10.36%)

Attachment 7-7(1) Example of Selection of Transformers Capacities

(1) Present Condition Data

Capacity of the transformer		200kVA
Number of 0.4kV feeders		2
Current (at Feb 7,1998)	Feeder1	122A, 67A, 86A(60.3kVA) total 275A
	Feeder2	40A, 67A, 57A(36.0kVA) total 164A
Conductor of main lines		70*4
Peak current at 1998 (estimated)	Feeder1	244A, 134A, 172A(127.0kVA) total 550A
	Feeder2	80A, 134A, 114A(72.0kVA) total 328A

(2) Condition

(a) Peak current

Feeder1	366A, 201A, 258A(187.3kVA)
Feeder2	120A, 201A, 171A(108.0kVA)

(b) Two cases considered

Case-1	Replacement to large capacity 400 kVA (Existng 200kVA transformer is used at another place not related)
Case-2	Installation of new 200 kVA transformer

Supposing that Low voltage feeders are same in both cases and main feeders are replaced from 70*4 to 120*4.

On calculation, we only consider resistance without impedance and admittance values mainly because of lack of information about electrical constant values of aluminum conductors used in Syria. We could get enough reliable and correct results with this method because impedance and admittance do not contribute largely to loss of low voltage feeders. If we had considered impedance and admittance, the difference of losses between case 1 and case 2 would be bigger. And in stead of resistance of aluminum, we use resistance value as aluminum with steel wire which resistance is not so quite different from aluminum.

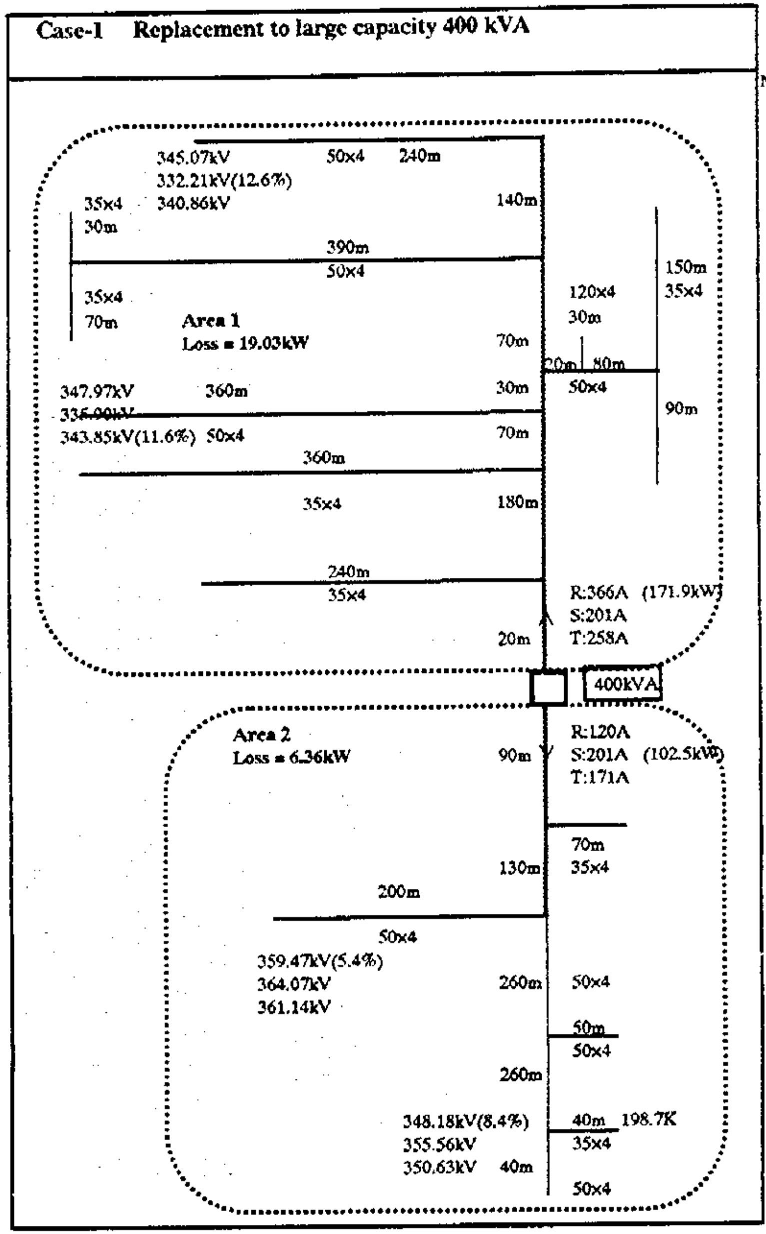
We neglect loss of transformer because the difference is small between two cases and also benefit to case-2. The system configurations are shown in Attachment 7-7(2). The result is shown in the following table.

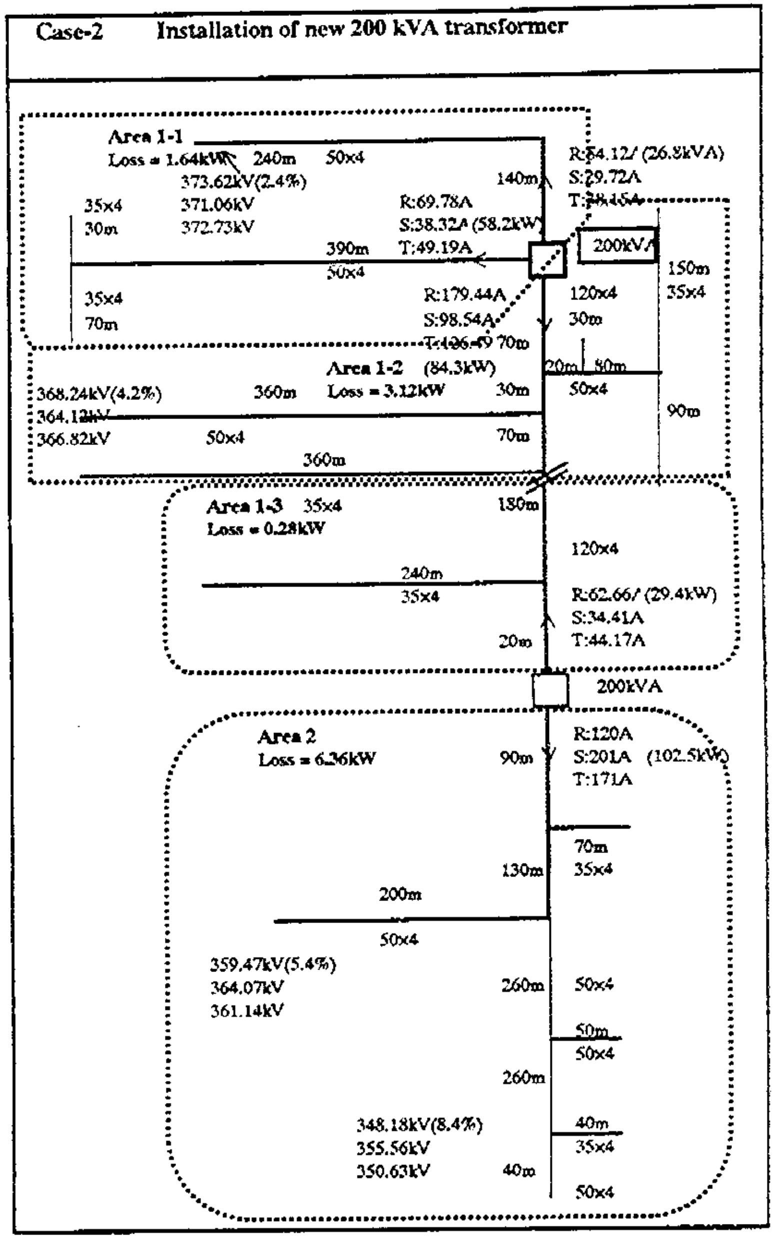
(3) Results

Case	Case-1 Replacement to a large capacity transformer	Case-2 Installation of a same capacity transformer
Supply at peak	274.4kW	274.4kW
Loss of 0.4kv feeders at peak	25.39kW	11.4kW
Energy Loss per year	25.39*8760*0.42=93,415 kWh/year 6,035 US$/year	11.4*8760*0.42=41,943 kWh/y 2,710 US$/year
Construction cost of Transformers	18,495-9,675 US$ 882 US$/year (Supposing Existing transformer is used for another not related place)	9,675 US$ 968 SP/year
Construction cost of new 20kv feeders	-	6,087 US$ (370 m) 609 SP/year
Total Cost	**6,917 US$**	**4,287 US$**

Supposing kWh cost=0.0646US$, construction cost of new 20kV feeders = 16,450 US$/km, yearly expense ratio 10%

Attachment 7-7 (2) System Configuration on Each Case





Attachment 7 - 8

Relation between Capacities of Transformers and Loss of Low Voltage Lines

A2 : Area (m^2)
D : Demand Density (kW/m^2)
C : Capacity of each transformer (kW)
$\cos\phi$: Power Factor
P : Power of each LV line (kW)
$P = \sqrt{3}VI\cos\phi$

The number of transformers at considered area is calculated from area demand divided by C

$$N = DA^2 / (C\cos\phi)$$

The number of lines at each transformer

$$F = (C\cos\phi)/P$$

So, the total number of LV lines is

$$NF = DA^2/P$$

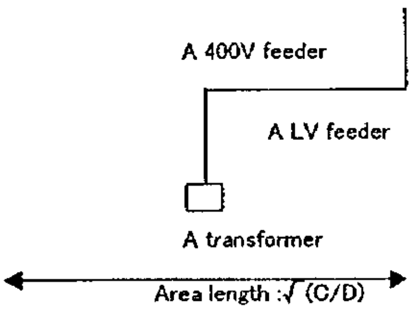
An area at each transformer is

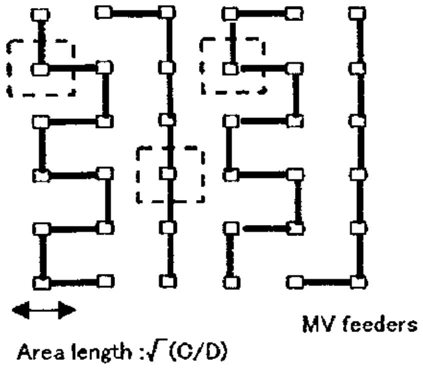
$$= A^2/N$$
$$= (C\cos\phi)/D\ (m^2)$$

Each LV line has the following length according to an area of each transformer except for branches

$$L = \sqrt{(C\cos\phi/D)}$$

So, Line-lengths of feeders at each transformer





$$FL = F\sqrt{(C\cos\phi/D)}$$

Total Line-length of feeders

$$NF\sqrt{(C\cos\phi/D)}$$

Finally, we get the following conclusion about loss of LV lines, supposing the load is equally distributed.

Total loss

$$= 3(1/3)\Omega NF\sqrt{(C\cos\phi/D)}I^2$$

$$= \Omega(DA^2/P)\sqrt{(C\cos\phi/D)}I^2$$

$$\boxed{\text{Loss Ratio} = \Omega(I/V)\sqrt{(C/D)}/\sqrt{(3\cos\phi)}}$$

Attachment 7-9 Outline of Simple Database System

1. Initial Setting Up

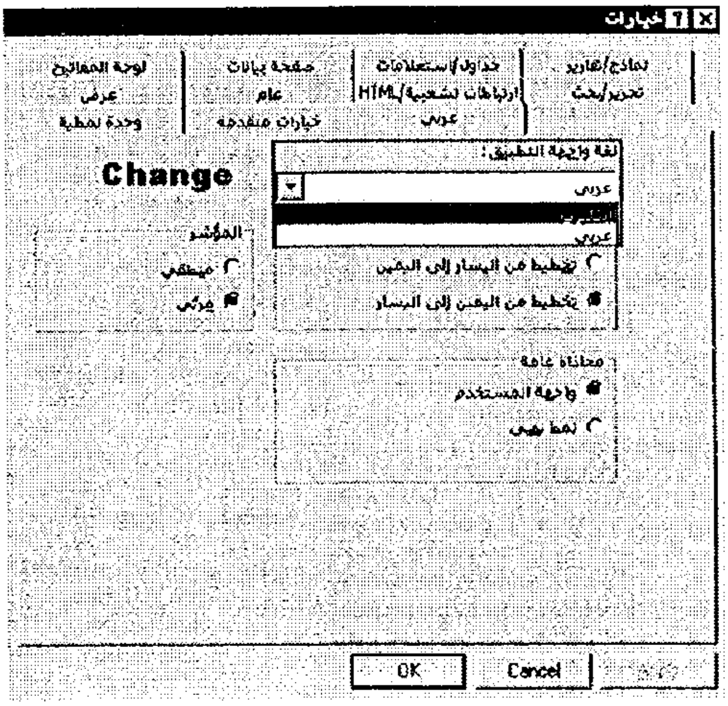
The following setting should be confirmed to operate software correctly.

(1) Setting of Microsoft "Access"

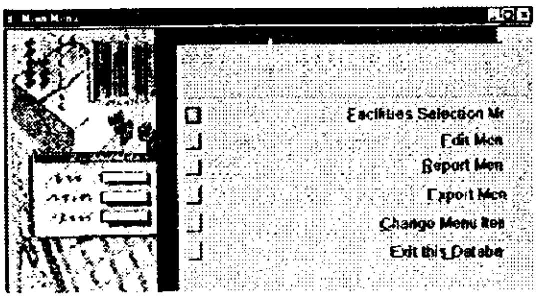
This database system is created by means of Microsoft "Access 97" of English version. The setting of display is necessary for correct function in the Arabic version. (The characters shall be displayed in the direction from right to left.)

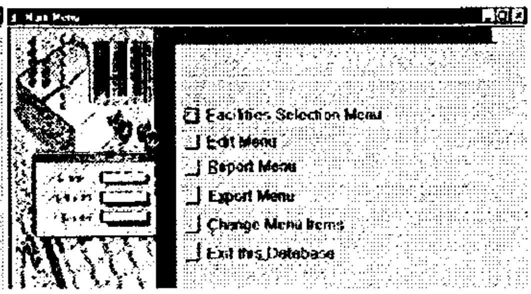
How to set:

"Tool" – "Option" – "Arabic Tab" -> Arabic → Change to English



- Before setting (Arabic)
- After setting (English)





(2) Setting of Browser

Browser which is necessary to open "Help file" shall be "Internet Explorer 4.01" or higher. The Help file does not operate correctly by other browsers or lower versions occasionally.

Confirm the following setting in the Internet Explorer.

"View" – "Internet Option" – "Advanced" -> Show Picture
"View" – "Internet Option" – "Security" – "Setting" -> Scripting Enabled
(The setting is slightly different depending on the version number of Internet Explorer.)

2. Operating environment

Personal computer which can operate the following OS and application softwares should be used.

Mocrosoft Windows 95, Windows 98, Windows NT4.0 (English version)

Microsoft Access 97

3. Operating Screen

(1) Main Menu

A main menu of the database system comprises those as shown in the Table A7.9-1.

Table A7.9-1 Items in Main Menu

Menu item	Contents
Facilities selection menu	Input facilities' information.
Edit menu	Edit facility items
Report menu	Display data in print format
Export menu	Export data to "Excel"
Change menu items	Setting of menu items
Exit database	Access end

When starting up the database system, a main menu as seen in the Fig. A7.9-1is automatically displayed.

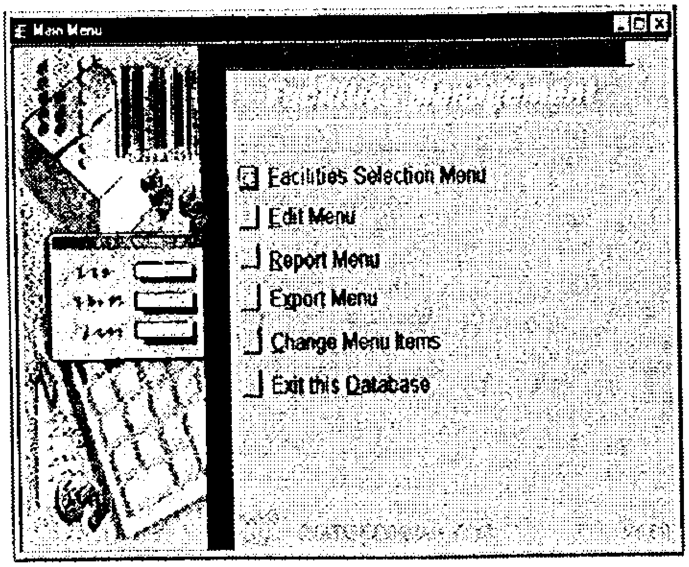


Fig. A7.9-1 Starting Display of the System(Main Menu)

Click a square button in menu by mouse or input an alphabet character underlined on keyboard to shift to the following menu.

When input data to the system, select the Facility Selection Menu and then input data for each management item. The data for regular items are selected from the drop down list, which shall be prepared beforehand. The drop down list shall be edited by edit menu. Attention shall be drawn to that new data shall be added at the bottom line. If a new datum is added in the middle of a series of data, the datum is replaced. Therefore, data items shall be prepared in the edit menu before data entry.

"Report menu" is used for printing, and the analyzing method of total data in each category is set up. Regular printing of the data is available by this setting.

Export menu is to convert the data for "Excel". As Excel is useful to easily edit the data, this menu converting the data to Excel is added.

Change of menu items is used to add or delete the menu item. Maximum eight menu items can be arranged in the display. This shall be used to expand menu items in future.

(2) Facility Selection Menu

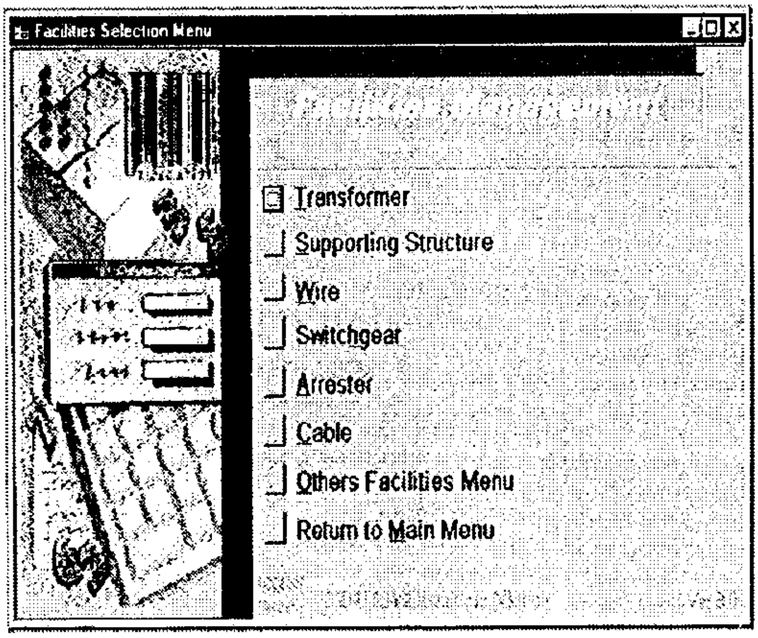


Fig. A7.9-2 Facility section menu(Main menu)

Facility selection menu is used to select a facility for data entry. Menu display comprises two screens. The screen moves by clicking the other facility item. By clicking the facility item, data input form is displayed.

Table. A7.9-2 Transformer Menu

Items	Contents
Transformer main menu	Basic information
Maintenance menu	Maintenance management record and operating records
Loading menu	Load management data

Transformer menu comprises three screens, and links with maintenance management records and loading management data.

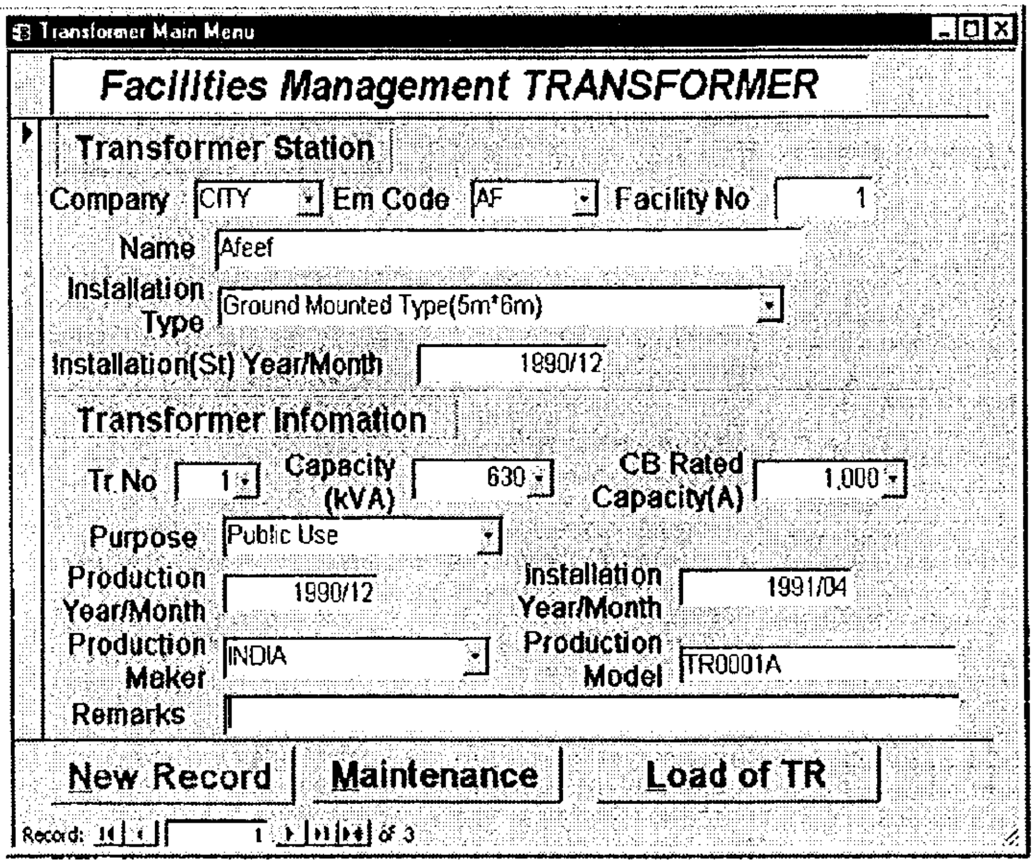


Fig. A7.9-3 Transformer Menu(Input format)

Figure A7.9-3 shows a main menu of the transformer. This input format consists of two parts, of which the upper part is used for transformer stations and lower part for transformers. A name of distribution company, a name of emergency office and a facility number are indispensable information in this format. Although transformers and the associated facilities have been managed by the name of place or location in the current management, it is necessary to change to the management system by means of facility numbers.

A drop down list is prepared for some input items which are marked with a triangle mark in the format as shown on the Fig. A7.9-4. By clicking buttons placed in the bottom of screen, the screen will change to a menu screen for new records, maintenance records and loading conditions respectively.

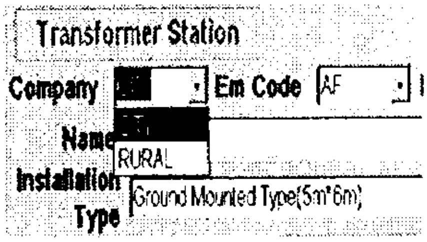


Fig. A7.9-4 Drop Down List

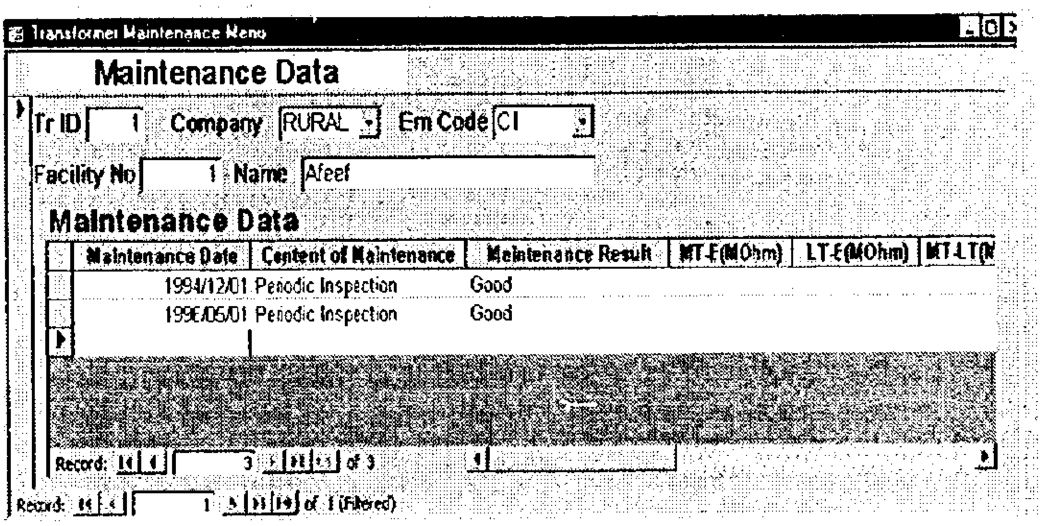


Fig. A7.9-5 Screeen of Management Record(Input format)

Fig. A7.9-5 will appear when "maintenance button" is clicked. This screen is an input format for maintenance records of transformers, e.g. inspection, insulation resistance measurement and other history of operating transformers. The maintenance format is linked with the transformer data in the main records. The screen is locked with the filter for preventing miss-input. For instance, a main menu of transformer No.1 of emergency office C1 will change to maintenance screen by clicking "maintenance button", where the information of the said transformer is able to be displayed or added. When input maintenance information of other transformer, return to main menu and select transformer No.2. Then the same procedure will be taken to obtain screen for maintenance of transformer No.2.

The screen as shown on the Fig. A7.9-6 will appear by clicking the loading control button in the main menu of transformers. The loading control system can manage load currents of three phases of transformers. The date and time of measurement are indispensable information to utilize this loading data effectively. The total currents and operation ratio are automatically calculated in the system, when input new data.

The database system for transformers was created based on the data and information which have been stored and maintained by the distribution companies. However, as for the distribution facilities other than transformers, all information and data have not been well sorted and maintained properly. Therefore, the block number is applied for each emergency office in the similar way as transformers. The block number shall be a number of four columns which is suitable for the database system. All supports in the area having the block number shall be numbered following the above stated manner.

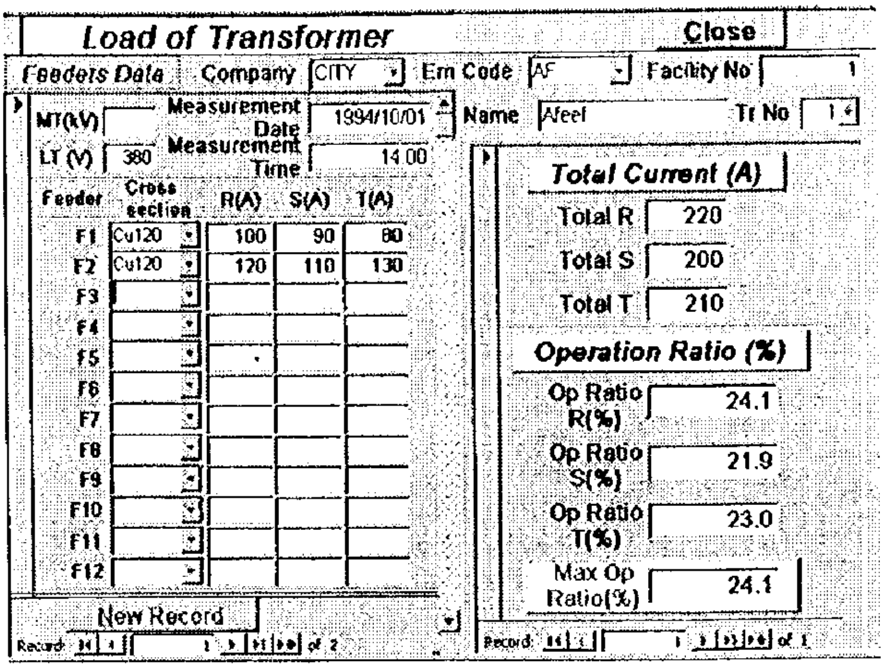


Fig. A7.9-6 Screen of Loading Control(Input Format)

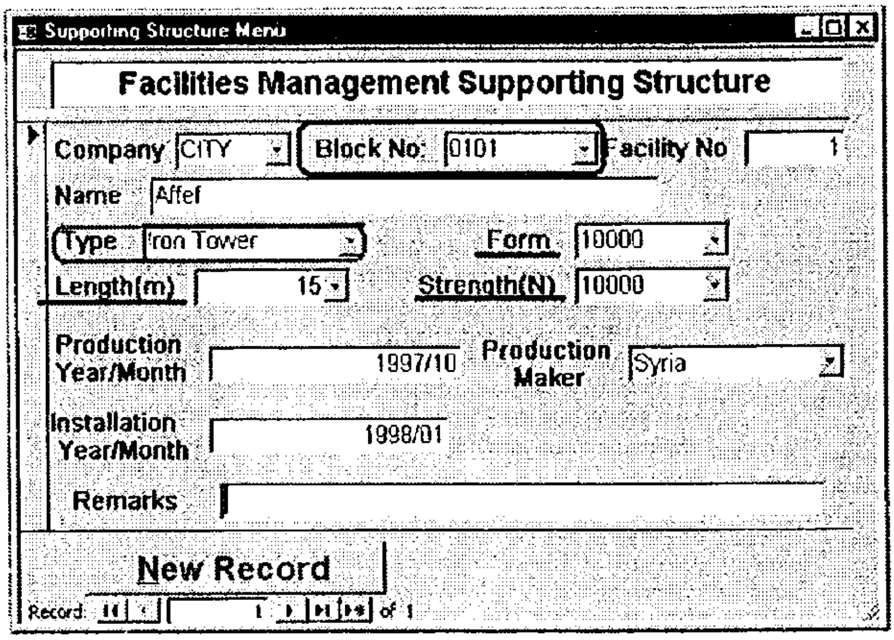


Fig. A7.9-7 Screen of Supporting Structures(input Format)

When input a type of supporting structure (steel towers, concrete poles, wooden poles), items for model, length and strength which are shown with underlined are automatically decided.

Fig. A7.9-8 is a screen for conductor management, where conductors and other facilities will be managed based on the number of supporting structures. The conductor is specified by the installed section between two supports. Fig. A7.9-8 shows that the conductors installed between support No. 1 and support No.2 in the block No. 0101 is three phases of AL120AS. The facilities concerned with conductors (line switches, arresters and others) are also controlled based on the support number.

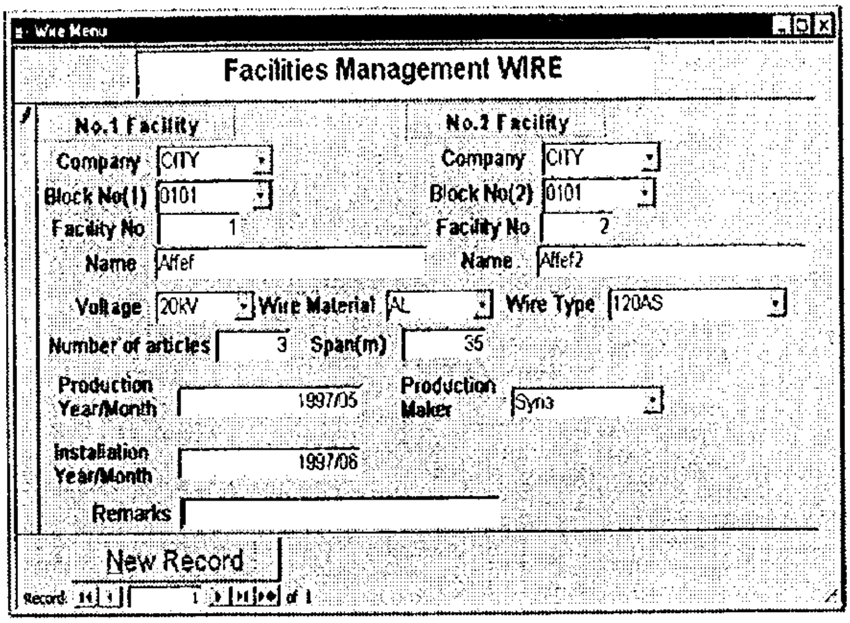


Fig. A7.9-8 Screen of Conductor Management (Input Format)

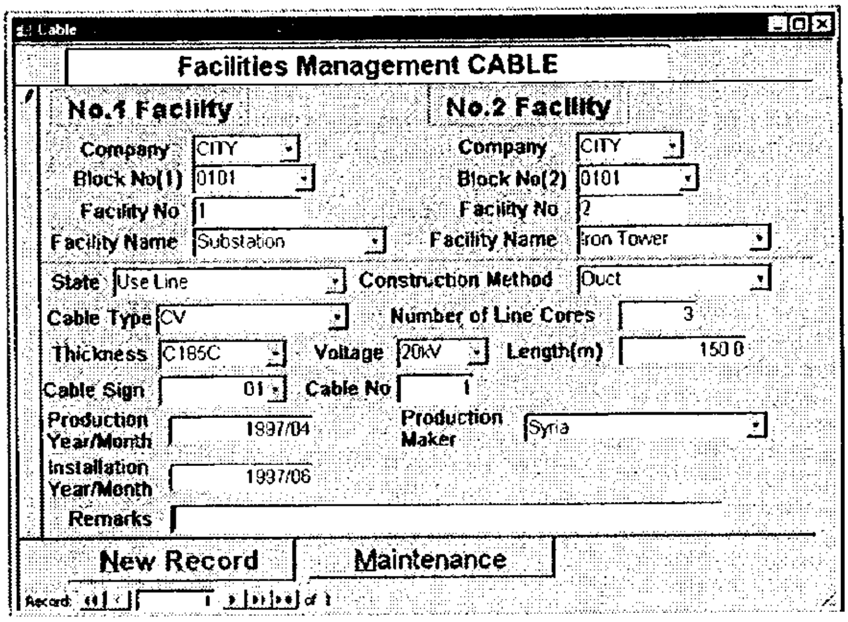


Fig. A7.9-9 Screen of Cable Management (Input Format)

Fig. A7.9-9 shows a screen of cable management for underground lines. Cables are managed by each facilities or equipment, not by supports in the overhead lines, and the installed section is specified by means of facilities number. In the Fig. A7.9-9, the cable is installed between substation No. 1 in the block No. 0101 and tower No.2 in the block No.0101. The control of maintenance and operating history will be available in the other screen by clicking the maintenance button.

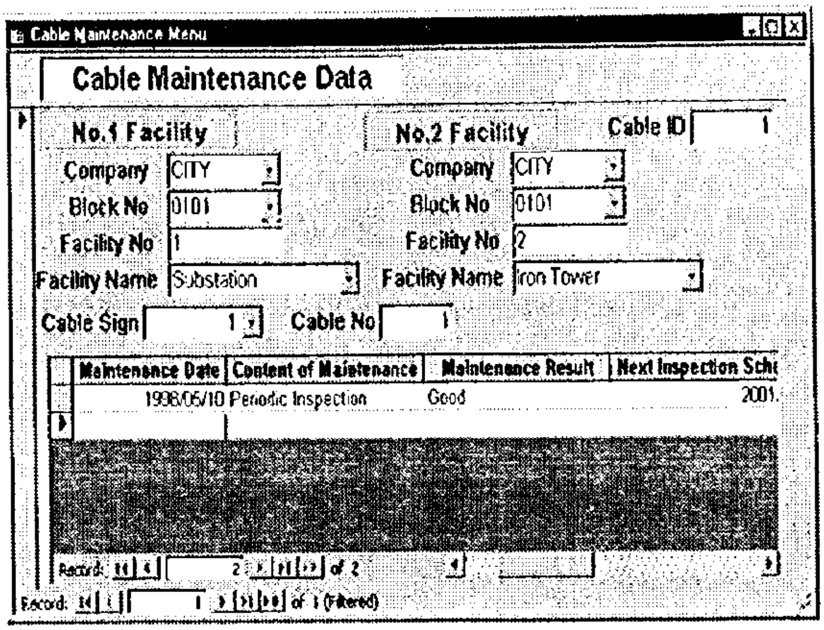


Fig. A7.9-10 Screen of Cable Management (Input Format)

The maintenance screen, as shown on the Fig. A7.9-10, shows results of maintenance, schedule for next maintenance and other information.

This attachment described mainly input screens for the facilities management. For the other menu or screens, please refer to the Help file attached to the database system.

CHAPTER VIII

IMPROVEMENT PLAN OF DISTRIBUTION SYSTEM IN THE STUDY AREA

Chapter 8 Improvement Plan of Distribution System in the Study Area

8.1 66 kV Facilities

8.1.1 Construction of New Substations

All the 66/20 kV substations planned by PEDEEE up to the year 2010 and those requested by the two Distribution Companies were carefully examined referring to the forecasted peak load of each substation and those of new substations (non-simultaneous peak loads) as explained in Sub-clause 4.2.3. Area loads were re-allocated among the existing and new substations taking account of specific development projects for residential towns or industrial zones planned by the Regional Governments, etc. Through careful examinations, the Team confirmed that all the substations planned by PEDEEE are necessary in the future 66 kV network, and their development plans are generally reasonable and appropriate.

In addition to the planned substations by PEDEEE as above, the Team proposes to construct a new Ersal substation in the center of Damascus City. It is noted that the peak load of the Ersal substation for city center supply is forecasted to grow at a high rate and reach 100 MW in around the year 2010, because there will be no other substation to take the Ersal's load. The Ersal substation is located in the heart of the city and its switchgear and two units of main transformers (20 MVA) are installed in the existing substation building, and it has no space available for addition of any facilities at the present location. Further, it will be quite difficult to find an enough space for new substation within the supply area of Ersal, except for the head quarter premises of the Damascus Distribution Company located adjacent to the substation. It is, therefore, recommended to review the construction of a new substation by re-developing the office building of head quarter adjacent to the existing Ersal substation. Appropriate location of the new substation will be the basement of building, that can accommodate up to four units of transformers and necessary GIS with a certain space for future extension. The completion of a new substation (3 x 40 MVA in initial stage) is required before 2002.

For the underground or narrow space installation, Gas Insulated Switchgear (GIS) are to be used for HV switchgear and compact switchgear cubicles for 20 kV circuits. Main transformers are usually of three component construction, main body (in equipment room), water heat exchanger (somewhere appropriate) and cooling tower (mostly on building roof). Details are to be studied according to site conditions.

The underground utilization of parks, wide squares, large new buildings, etc. shall be taken into account in planning new GIS substations in the city center area. In Tokyo, there are many examples of underground utilization of parks, etc., and in the city center most of substations are located in the basement of large private buildings. Power utility lends underground spaces on payment of certain charges. The largest underground substation in Tokyo is a 500 kV substation that is now under construction, and there are a number of examples of 275/154/66 kV substations.

The proposed new substations up to the year 2010 are summarized as follows:

Table 8.1-1 Summary of Proposed New Substations

Period	Up to 2002	2003 – 2005	2006 - 2010
230/66 kV substations	Mazzrha Zahera	-	Baramekha Al Faihaa Saiedeh Zanab
66/20 kV substations	Thirteen (13) substations Kafersuseh Harash Khan Al Shih Barzeh Zablatani Ibn Al Nafis Jalaa Hosh Blas Sheik Hassan Qsoor Jaramana Al Feigha New Ersal	Three (3) substations Yalda Jededat Artouz Bludan	Eight (8) substations Al Tal Yabroud Harasta Nashabieh Meleha Kudseia 1 Kudseia 2 Darea

All 66 kV lines that are required to connect the new substations and the existing 66 kV network shall be planned along with the construction of new substations.

8.1.2 Increase of Transformer Capacity

The schedule of increasing transformer capacities for each substation in the Damascus and Damascus Rural area was prepared as shown in Table 8.1-2, based on the peak load forecast by substation including new substations (non-simultaneous peak loads). The summary of increasing transformer capacities is shown in Table 8.1-3.

Table 8.1-3 Summary of Procurement Schedule of Transformers

Period	Up to 2002	2003 - 2005	2006 - 2010
Transformer, 50 MVA	-	6	2
Transformer, 40 MVA	5	-	9
Transformer, 30 MVA	15	3	10
Transformer, 20 MVA	1	-	-

It is noted that, as 2 units of 5 MVA transformer in Al Matar substation and 1 unit of 20 MVA transformer in Adra 1 are exclusively used for the international airport and waste water treatment plant respectively. These transformers are considered to remain as they are during the study period and not considered in preparing the schedule of increasing transformer capacities. However, it is recommended to consider in detail construction of new substations in the same areas for meeting the growing power demand in future.

It is required that all of new transformers to be procured shall be of 30 MVA and 40 MVA in unit capacity. For small capacity development in rural areas, 20 MVA or 10 MVA transformers removed from the existing substations can be utilized

In case of transformer addition to a substation, arrangement of new transformer feeder bays shall also be reviewed in design and cost estimate.

8.1.3 Replacement of 20 kV Switchgear Cubicles and 20 kV Circuit Breakers

The replacement plans of 20 kV circuit breakers and/or complete 20 kV switchgear cubicles in the Damascus and Damascus Rural area are scheduled as shown in Table 8.1-4 and summarized below:

Table 8.1-5 Summary of Replacement of 20 kV Switchgear

Period	Up to 2002	2003 - 2005	2006 - 2010
Replacement of 20 kV circuit breakers	155 sets of in total	117 sets in total	-
Replacement of complete 20 kV switchgear including circuit breakers	Two (2) substations Ashmar Thawra	Five (5) substations Mazzrha Bab Sharki Nebek Al Hameh Al Matar	Ten (10) substations Al Hajar Al Aswad Al Jamha Dummar Sydanaya Zabadani Fursan Izaa Kisweh Maarad Al Faihaa

8.1.4 Reinforcement of 66 kV Network

According to the results of power flow analysis for three stages in the years 2000, 2005 and 2010, the 66 kV network needs to be reinforced by adding new lines or by replacing conductors with those of larger cross section. The following are recommended reinforcement plans of each stage.

(1) Network Extension by 2000

Certain overloading of 66 kV lines may appear under the contingency conditions (N-1 criteria) as explained in Clause 7.4.2. However, these overloadings will be solved with the completion of 230/66 kV substations at Mazzrha and Zahera. The contract for the construction of these two substations is under evaluation by PEEGT and expected to be commissioned in 2002. It is proposed to wait the commissioning of these two 230 kV substations without network reinforcement of the concerned sections, although the reliability may be slightly aggravated during the period before commissioning of the two substations.

(2) Network Extension by 2002

The following reinforcements will be required to maintain system reliability based on N-1 criteria:

(a) With the commissioning of Zahera 230 kV substation, an underground line with cross section of Cu. 630 mm^2 shall be added for interconnection between Sheikh Hassan, Dawar Al Matar and Bab Sharki and an overhead line between Al Hajar Al Aswad and Zahera shall also be added.

(b) Certain 66 kV lines are required to connect new substations with the 66 kV network.

(3) Network Extension by 2005

The following reinforcements will be required to maintain system reliability based on N-1 criteria:

(a) Midan II - Al Hajar Al Aswad overhead line shall have a larger transmission capacity. The underground cable of Cu. 630 mm^2 is proposed.

(b) Underground cable line of the Mazzrha - Ersal is to be added with the commissioning of the Mazzrha 230 kV substation. The size of cable shall be of Cu. 630 mm^2.

(c) The second circuit shall be added to the section of Adra II - Kotaife - Sydanaya to increase transmission capacity to meet the growing power demand in the related area.

(d) The second circuit shall also be added to the section of Adra II - Adra I and Qaboon II - Duma in consideration of operation under contingency conditions.

(e) The second circuit shall be added to the section of Kisweh - Al Maarad to increase transmission capacity.

(f) Certain 66 kV lines are required to connect new substations with the 66 kV network.

(4) Network Extension by 2010

To maintain the stable power supply to consumers in the year 2010, the following reinforcement and/or additional lines are required to the 66 kV network by the year 2010:

(a) The underground cable line (Cu. 300 mm^2) in the section of Mazzrha - Thawra shall be replaced with Cu. 630 mm^2.

(b) The second circuit shall be added to the section of Kotaife - Nabek to increase transmission capacity to meet the growing power demand in the related area.

(c) The second circuit shall be added to the section of Dimas - Switching Station in Zabadani area to increase transmission capacity.

(d) The overhead line of Al Maarad - Saiedeh Zinab - Yalda shall have a larger cross section to increase its transmission capacity, e.g. 400 mm^2 or 550 mm^2, with the commissioning of Saiedeh Zinab 230 kV substation.

(e) An additional underground cable line of Cu. 630 mm^2 for the section of Midan II - Baramekha - Ersal is required with the commissioning of Baramekha 230 kV substation.

(f) Certain 66 kV lines are required to connect new substations with the 66 kV network.

8.1.5 Installation of Static Capacitors

In accordance with the result of power flow analysis for the 66 kV network in the study area, static capacitors are required to regulate the bus voltage of all substations within the allowable range. For this purpose, static capacitors shall be installed on the 20 kV busbars of 66/20 kV substations with the following schedule:

Table 8.1-6 Static Capacitors to be Installed

(in MVar)

	2002	2005	2010
Required Static capacitor (Total)	385	585	755
Existing installed capacity	35	-	-
Under installation by PEDEEE	175	-	-
Included in the construction of new substations	110	30	70
Additional capacitors to be installed	65	170	100

Note: PEDEEE plans to include static capacitors of 10 MVar for each substation in contracts for new substations.

The above additional capacities of static capacitors are to be proposed in the project lists.

8.1.6 Replacement of 66 kV Circuit Breakers

Three phase short-circuit current at 66 kV busbars of all the substations in the study area was calculated as mentioned in Clause 7.4.1. As recommended in the Standards for Substations, all 66 kV circuit breakers for new purchase shall have a short-circuit breaking current of 31.5 kA. For the existing 66 kV circuit breakers, the rating of short-circuit breaking current shall be compared with the calculated current of each substation. If the calculated short-circuit current is larger than the installed rating, the circuit breakers shall be replaced with those with larger rating. The replaced 66 kV circuit breakers can be used for rural stations with smaller short-circuit current. The schedule of replacement of 66kV circuit breakers is shown in Table 8.1-7

Table 8.1-7 Summary of Replacement of 66 kV Circuit Breakers

Period	Up to 2002	2003 – 2005	2006 – 2010
Replacement of 66kV circuit breakers	24 sets in total Three (3) substations Mazzrha Amaween Midan I	30 sets in total Four (4) substations Mazzhe Qaboon II Al Hajar Al Aswad Fursan	11 sets in total Two (2) substations Adra II Al Hameh

8.1.7 Capacities of 230/66 kV Transformers

According to the results of power flow analysis as described in Clause 7.4, peak load flows in the 230/66 kV transformers of 230/66 kV substations will vary as mentioned in Table 8.1-6.

Table. 8.1-8 Peak Load Flows in 230/66 kV Transformers

230/66 kV Substations	Existing/Planned Installed Capacity (Nos. x MVA)	Existing/Planned Total Capacity (MVA)	2000 (MVA)	2005 (MVA)	2010 (MVA)
Adra II	2x125+1x80	330	263	345	331
Qaboon II	3 x 70	210	221	206	172
Dummar	2 x 80	160	167	120	208
Dimas	2 x 125	250	135	165	218
Fursan	2 x 125	250	107	144	171
Midan II	3x70+1x80	290	250	180	216
Kisweh	2 x 125	250	156	170	193
Mazzrha	3 x 125	375		230	315
Zahera	3 x 125	375		215	206
Baramekha	2 x 125	250			148
Al Faihaa	2 x 125	250			166
Saiedeh Zanab	2 x 125	250			150

The load flows of all substations except for the following three substations were within the installed capacities of transformers up to the year 2010. Team's comments on anticipated countermeasures are as follows:

(a) Adra II : Peak load in 2000 is 263 MVA and will increase to 331 MVA in 2010. It is recommended to install one 125 MVA unit by replacing 80 MVA unit preferably by the year 2005. Thus, total capacity will be 3x125 MVA (375 MVA), larger than the forecast load flow.

(b) Qaboon II : Peak load will increase to 221 MVA in 2000 but decrease to 206 MVA in 2005 and further to 172 MVA in 2010. Overloading in 2000 will dissipate by the commissioning of two 230/66 kV substations of Mazzrha and Zahera in 2002. Thus addition of transformer will not be required.

(c) Dummar : Peak load in 2000 is 167 MVA slightly over the rated 160 MVA. After decreased to 120 MVA in 2005, the load will increase to 208 MVA in 2010. The third unit of 80 MVA transformer is required before 2010 (240 MVA in total). Overloading in 2000 can be solved by shifting load to other substations and finally dissipate by the commissioning of the Mazzrha substation.

It is recommended to take the above measures to increase transformer capacities. This matter shall be consulted to PEEGT.

8.2 20 kV Facilities

8.2.1 Construction and Reinforcement of 20 kV Main Feeders

(1) Construction of 20 kV Main Feeders

The construction and expansion of 20 kV main feeders shall be implemented according to the plans prepared in advance taking into account a rapid increase of power demand. As mentioned in section 7.6, to maintain the supply reliability, 20 kV main lines shall be provided with standardized conductor, e.g. 120AS for overhead lines and 185AL for underground lines, and the peak current shall be limited within 50% of the rated current capacity of these conductors or, in other words, within 160 A, in order to allow power transfer by interconnection with other feeders in case of fault.

In preparing improvement plans for 20 kV main lines of the study area, total quantities of components/materials required for implementation of the rehabilitation and improvement plans of 20 kV main lines were estimated in such a manner as mentioned below, as the detailed study for all 20 kV feeders of the study area is physically not possible because there are a great number of 20 kV feeders available in the study area.

Damascus City Distribution Company

As most of 20 kV feeders in the Damascus City are cable lines and arranged in the open-loop system, all the 20 kV feeders are regarded as main feeders. In preparing the construction plan for 20 kV main feeders, peak currents of all 20 kV feeders in the study period were estimated on the basis of peak currents of the existing feeders shown on Table 5.3-5 in Chapter 5 and the power demand forecast in Chapter 4, where the construction of any additional new feeder line is not considered. As shown in Table 8.2-1, the number of feeders , of which peak currents in 2010 will exceed 50% of the rated current of 20 kV power cable or 160 A, is counted for 101 out of 299 feeders in total. Two feeders out of 101 feeders will have over 320 A of peak current.

Table 8.2-1 Peak Currents on 20 kV Feeders at Delivering Point (Damascus City)

(unit : Number of feeders)

Peak current at delivering point	1997	2000	2005	2010
Above 320 A	0	0	1	2
260 A - 320 A	0	0	0	16
160 A - 260 A	2	9	39	83
131 A - 160 A	16	22	40	30
101 A - 130 A	22	59	43	52
1 A - 101 A	259	209	176	116

Accordingly, to share loads of these heavy loaded feeders having over 150 A peak currents, new 20 kV feeders shall be constructed adjacent to these feeders. The required number of new 20 kV feeders is estimated at approximately 110.

Damascus Rural Distribution Company

34 feeders in 20 kV system were selected as shown in Table 8.2-2 for the detailed study of the rehabilitation program. The detailed rehabilitation program was studied for each selected 20 kV feeder in order to secure stable power distribution of the forecasted power demand in 2005 and 2010. Figure 8.2-2 (1) - (4) show the detail rehabilitation programs for the selected 37 feeders in 20 kV system. As shown in these figures, it is considered in the study that new 20 kV feeders shall be constructed where the existing feeders would be heavily loaded due to the increase of power demand and become difficult to transfer further loads in case of fault. As a result, it is found that 22 additional new feeders until 2010 will be required to be constructed in case of the selected 34 feeders. With assumption that the other remaining feeders in Damascus Rural area may require the construction of 20 kV new feeders in the similar ratio with that of the sample feeders. The total number of new 20 kV feeders in Damascus Rural area was estimated 100 additional new feeders until 2010. Further, as shown in Figure 8.2-1(1)-(4), inter-connections with other feeders will also be required in accordance with increase of power demand. The number of new connections with other feeders for Damascus Rural Distribution Company is also estimated in the same manner.

To obtain total quantities of components/materials for construction of new 20kV feeders, the composition of typical 20kV main line is assumed as shown in the Table 8.2-3.

Table 8.2-3 Averaged Composition of additional New 20 kV Feeders and Connections

Area	Construction of main feeders	Construction of connections
Damascus City	C185AL 2 km	-
Damascus Rural	120AS 3 km, C185AL 0.5 km, OC185AL 0.1 km	120AS 2 km

Lengths of 20 kV lines required for connection of new transformers to the system were estimated based on the number of new transformers required mentioned in Section 8.3. The length of feeder at one transformer connection is assumed as shown in Table 8.2-4.

Table 8.2-4 Average Length of Service Wires for New Transformers

Area	Construction of connecting feeder
Damascus City	Underground Cables C185AL: 10 m at a transformer
Damascus Rural	Overhead Lines: 0.2 km at a transformer

From the above study, the required lengths of construction of 20 kV main feeders, connections with other feeders and connecting feeders required for new transformer installation in the study area are obtained as shown in Table 8.2-5. The total quantities up to 2010 are supposed to be implemented equally every year, as the detail study on the individual facilities is not applicable in case of 20 kV facilities.

Table 8.2-5 Total Quantity of Construction of 20 kV Main Feeders (unit : km)

Company	Sub-project	2000-2002	2003-2005	2006-2010	Total
City	Construction of 20 kV Underground Cables 185AL	60	60	100	220
	Construction of 20 kV Underground Cables 185AL (For connection of transformers)	4	4	8	16
Rural	Construction of 20 kV Overhead Lines 120AS	77	77	208	362
	Construction of 20 kV Underground Cables 185AL	13	13	32	57
	Construction of 20 kV Overhead Cables 185AL	3	3	6	12
	Construction of 20 kV Overhead Line (For connection of transformers)	140	140	200	480
	Total	297	297	554	1,147

(2) Reinforcement of 20 kV Main Feeders

As mentioned in Chapter 7.6, the reinforcement of 20 kV feeders will be required to continue every year according to the annual increase of power demand, for securing the supply reliability.

For 20 kV underground feeders in Damascus City, the objectives of reinforcement of feeders are 20 kV cable feeders having the cross section of less than 185 mm². Although the detailed information about types of conductors and lengths of all feeders were not available to the Team, the team received the data of cables of 111 km in total length, which corresponds to 5 % of total 20 kV feeders of Damascus City. According to the above data, approximately 70% of all cables in the data are having the cross section of less than 185 mm². The estimated peak currents of all feeders in 2010 are shown in Table 8.2-1, where new additional feeders and/or reinforcement of feeders are not considered. The number of feeders having peak currents exceeding over 130 A or 50% of the rated current capacity of 120 mm² (under 185 mm²), is 131 out of 299 feeders in total, namely 45% of all feeders in the City area. Therefore, the number of 20 kV feeders which require reinforcement until 2010 is estimated at approximately 45% of 20 kV feeders having the cross section of less than 185 mm². The total length that requires reinforcement is about 600 km. For the other remaining feeders the reinforcement will not be necessary until 2010. The reinforcement work of 20 kV feeders in Damascus City is supposed to continue every year in the same pace during the study period.

As for 20 kV feeders in Damascus Rural area, as mentioned in (1) Construction of 20 kV Main Feeders, the detail rehabilitation program was made in 34 sample feeders as shown in Figure 8.2-1(1)-(4), in which the length of reinforcement required for 34 samples feeders was found. The required quantities of reinforcement of 20 kV feeders for all Damascus Rural area were estimated from the result of study on 34 sample feeders.

The lengths of reinforcement of 20 kV feeders in each distribution company are as follows.

Table 8.2-6 Total Quantities of Reinforcement of 20 kV Main Feeders (unit : km)

Company	Sub-project	2000-2002	2003-2005	2006-2010	Total
City	Reinforcement of 20 kV Underground Cables 185AL	164	164	272	600
	Reinforcement of 20 kV Overhead Lines 120AS	229	229	278	736
Rural	Reinforcement of 20 kV Underground Cables 185AL	35	35	10	80
	Reinforcement of 20 kV Overhead Cables 185AL	15	15	7	37
	Total	443	443	567	1,453

8.2.2 Replacement of Deteriorated Oil-Impregnated Paper-Insulated Cables

The aged and deteriorated oil impregnated paper insulated cables shall be urgently replaced with CV (XLPE and PVC sheathed) cables. Thus the replacement work in both Damascus City and Damascus Rural has planned to be finished by the year 2002. The total quantity of 20 kV CV cables for replacing old oil cables is shown in Table 8.2-7.

Table 8.2-7 Length of Oil-Cables to be Replaced (unit : km)

Company	Sub-project	2000-2002	2003-2005	2006-2010	Total
City	Replacement of 20kV Old Oil Impregnated Paper Insulated Cables to 185AL	173.7	0	0	173.7
Rural	Replacement of 20kV Old Oil Impregnated Paper Insulated Cables to 185AL	33.6	0	0	33.6

8.2.3 Installation of Section Switches

As mentioned in Clause 7.6.1, section switches with auto fault detecting devices and terminal on-load switches are to be installed on 20 kV main feeders on the purpose of adaptation of multi divided and multi connected systems in 20 kV systems in order to enhance the system reliability.

Table 8.2-8 shows the number of feeders, fault detecting switches and terminal on-load switches required for existing feeders classified by peak current.

Table 8.2-8 Number of Existing Feeders and Required Section Switches

Peak currents at delivering point	City	Rural	Total	Fault Detecting Switches	Terminal on-load switches
Above 161 A	1	12	13	39	6
101 A - 160 A	39	48	87	261	44
51 A - 100 A	124	54	178	356	89
1 A - 50 A	134	93	227	-	-
Unknown	0	3	3	-	-
Total	298	210	508	656	139

The above table shows the number of switches to be installed on the existing 20 kV main feeders. The number of section switches and terminal on-load break switches are to be added along with the growth of power demand. The total numbers of section switches and terminal on-load break switches to be installed during the period of 2000 to 2010 are estimated taking into account the required quantities for the existing system and the growth of power demand. The total quantities of section switches with auto fault detecting device and terminal on-load break switches are shown in Table 8.2-9.

Table 8.2-9 Quantities of Section Switches and On-load Break Switches

Company	Projects	2000-2002	2003-2005	2006-2010	Total
City	Auto vacuum switches	283	283	204	770
	Terminal on load switches	63	63	45	171
Rural	Auto vacuum switches	262	262	248	772
	Terminal on load switches	52	52	49	153

Auto vacuum type section switches are to be installed at several positions in 20 kV main feeder as well as its auxiliary devices, e.g. 20 kV auto fault detecting devices and 20 kV/100 V transformers for power source. The section switches shall be installed at several positions so that each section has at least 1 MVA (about 50 A) load as mentioned in Section 7.6.2 (h). The detailed layout of section switches on feeders is referred to the Attachment 7.3, item 3.4 " Section Switches" and the detail explanation how to detect the fault point is referred to the Section 9.3. Further, at the control panel of 20 kV outgoing feeder at substation, a fault point indicator shall be mounted on the panel for each feeder, which will indicate the faulted section on the feeder. At the end of main feeder, a terminal on-load switch shall be installed to connect with other feeder in case of fault for immediate power transfer.

8.3 Low Voltage Distribution Facilities

8.3.1 Installation of 20/0.4 kV Transformers

As mentioned in Section 7.7.2, 20/0.4 kV distribution transformers should regularly be added to particular spots of distribution network according to the growth of area demand. The same capacities of distribution transformers as the existing ones, not a larger capacity of the existing, in the area are to be added. It was found through the case study for the selected low voltage distribution network that the existing transformers installed in the sample area are generally adequate to the existing load density in terms of unit capacity, and the transformers of the same unit capacity with the existing ones are economically feasible to be added to the system even under the double load density. Details are described in Section 13.3. Therefore, it is concluded that the application of the same unit capacity with the existing transformer is a proper measure to increase distribution capacity.

Based on the above conditions, the quantities of 20/0.4 kV transformers required for the Study Area until 2010 were estimated in the following way.

Based on the detail information about a number of the existing transformers corresponding to approximately

12 % of all transformers in Damascus City, the number of transformer and the peak load ratio to the rated capacity of transformers in 1998 were obtained for each unit capacity of transformer. For Damascus Rural area, the data of all the existing transformers installed in the 38 emergency offices, which correspond to approximately 80 % of all transformers in the Damascus Rural area, were examined in the same way. The quantity and the peak load ratio for each unit capacity of the existing transformers in the selected sample areas are shown in Table 8.3-1 for Damascus City and Table 8.3-2 for Damascus Rural area respectively.

Assuming that peak load at the transformer station will increase with the same pace as growing power demand, peak load ratios of all transformers were estimated for the years 2002, 2005 and 2010. From the result, the required quantities of transformers for the selected sample areas were calculated, with condition that a transformer of the same capacity with the existing one shall be added only when the peak load ratio of the existing transformer exceeds 100 %. The required quantities of transformers for the selected sample areas in the Damascus City and Damascus Rural area are shown in the Table 8.3-3 and Table 8.3-4 respectively.

Table 8.3-1 Quantities of Transformers in Sample Area (City in 1998) (unit : number)

Peak load	Capacity of 20/0.4 kV transformers (kVA)								Total	Share
ratio	200	250	315	350	400	630	1000	1600		
0 – 19 %					4	2	1		7	3%
20 – 39 %	4				3	13	2		22	11%
40 – 59 %		1		1	6	21	4	2	35	17%
60 – 79 %	2				12	31	2		47	23%
80 – 100 %	2		1		16	48	2	1	70	34%
Over 100 %					4	18	1		23	11%
Total	8	1	1	1	45	133	12	3	204	100%

(Note: Overloaded)

Table 8.3-2 Quantities of Transformers in Sample Area (Rural in 1998) (unit : number)

Peak load	Capacity of 20/0.4 kV transformers (kVA)											Total	Share
ratio	50	100	160	200	250	315	400	500	630	1000	1600		
0 – 19 %	1	7		15			16		14			53	4%
20 – 39 %	1	14		47	1		19		21		6	109	8%
40 – 59 %	1	25	1	53			46	3	50	4	2	185	14%
60 – 79 %	1	25		83	1	1	124		93	8	8	344	26%
80 – 100 %	6	13		68		4	109	2	131	12	6	351	26%
Over 100 %	0	3	0	64	2	6	127	1	86	5	0	294	22%
Total	10	87	1	330	4	11	441	6	395	29	22	1,336	100%

(Note: Overloaded)

Table 8.3-3 Quantities of 20/0.4 kV transformers (Sample area in Damascus City)

Unit Capacity	1998 (existing)	To 2002	To 2005	To 2010
200 kVA	8	2	1	1
250 kVA	1	-	-	-
315 kVA	1	-	-	-
350 kVA	1	-	-	-
400 kVA	45	15	10	16
630 kVA	133	57	26	39
1,000 kVA	12	2	2	4
1,600 kVA	3	1	0	0

Table 8.3-4 Quantities of 20/0.4 kV transformers (38 emergency offices in Damascus Rural)

Unit Capacity	1998 (existing)	To 2002	To 2005	To 2010
50 kVA	10	6	2	6
100 kVA	87	27	19	38
160 kVA	1	-	-	-
200 kVA	330	167	74	195
250 kVA	4	-	-	-
315 kVA	11	-	-	-
400 kVA	441	298	135	276
500 kVA	6	-	-	-
630 kVA	395	247	94	254
1,000 kVA	29	21	4	21
1,600 kVA	22	10	4	8

To estimate the total quantities of 20/0.4 kV transformers for the whole 20 kV system in the Study Area, the results of investigation on required numbers of 20/0.4 kV transformers for the selected sample areas were adjusted by applying the results to the remaining areas taking into account the total power demand. Table 8.3-5 and Table 8.3-6 show the estimated quantities of 20/0.4 kV transformers needed for installation in the Damascus Distribution Company and Damascus Rural Distribution Company respectively.

Table 8.3-5 Quantities of 20/0.4 kV transformers (City)

Unit Capacity	1998 (existing)	To 2002	To 2005	To 2010
200 kVA	71	18	9	9
250 kVA	9	-	-	-
315 kVA	9	-	-	-
350 kVA	9	-	-	-
400 kVA	401	134	89	142
630 kVA	1,184	507	231	347
1,000 kVA	107	18	18	36
1,600 kVA	27	9	0	0

Table 8.3-6 Quantities of 20/0.4 kV transformers (Rural)

Unit Capacity	1998 (existing)	To 2002	To 2005	To 2010
50 kVA	13	8	2	8
100 kVA	109	36	26	49
160 kVA	1	-	-	-
200 kVA	413	223	98	243
250 kVA	5	-	-	-
315 kVA	14	-	-	-
400 kVA	551	398	180	379
500 kVA	8	-	-	-
630 kVA	494	330	125	347
1,000 kVA	36	28	6	28
1,600 kVA	28	13	6	11

8.3.2 Reinforcement and Construction of Low Voltage Feeders

(1) General

The low tension distribution network has already been developed in a considerably wide range in both Damascus City and Damascus Rural area. As stated in the Chapter 5, there are many types of conductors and cables employed in the existing low voltage system and the quantities of used conductors and/or cables in terms of types and cross section are not available to the Team during the site investigation.

Although it is definitely necessary to construct new low voltage feeders, to reinforce feeders by replacing the existing conductors/cables with conductor/cable of larger cross section and to install additional distribution transformers according to the growth of power demand in future, it is not always necessary for all the low voltage feeders taking into account the estimated peak load in the year 2010. Therefore, the detailed study in the rehabilitation and improvement plans on the model areas selected for case studies, which have typical and average overhead and underground feeders, was carried out at first. The required quantity of reinforcement and construction of low voltage distribution feeders for whole area in the Damascus and Damascus Rural area are estimated from the result of the studies on the sample model area.

Especially for overhead feeders, it is difficult to estimate the required quantities of low voltage feeders by simply applying the same growth ratio with the growth of power demand. The low voltage overhead distribution network frequently changes their nature in the system configuration by adding new transformers to the system, which sometimes requires reinforcement of feeders. For instance, a certain section of feeder having conductors of smaller cross-section had have a sufficient current capacity to the peak currents when it had been located at the end of feeder. But once transformer was installed close to this section, the peak current flowing in this section may drastically increase, and the reinforcement of the feeder conductors will be required by applying the larger cross section of conductors. As such, the required quantities of reinforcement and construction of new overhead distribution feeders are estimated on the basis of the result of the case studies mentioned in the Chapter 13.

(2) Reinforcement and Construction of Overhead Lines

Assuming that the share of overhead lines is 70 % for Damascus City and 95 % for Damascus Rural area and increase of power demand in the new developing area, i.e. a new town construction, is one % of total increase of power demand for Damascus City and 10 % for Damascus Rural. Required quantities of reinforcement and construction of low voltage feeders estimated from the result of the case studies (Table 13.1-1 'Quantities required for reinforcement and construction for each stage and Table 13.1-2 'Total Quantities of Facilities in each year').

The quantities required for reinforcement and construction of low voltage feeders for both Damascus City and Damascus Rural is shown in Table 8.3-7. As the replacement of the existing bare conductors by vinyl insulated conductors was found to be required in 3 % of the total existing overhead conductors in the selected model areas, to prevent illegal connection by consumers and to protect people from accident. It was planned to apply the vinyl insulated conductors to 3% of the existing overhead feeder length in 1998 as the result of the detailed site investigation by the Team. When the reinforcement of low voltage feeders is executed, the vinyl insulated conductors will be used during the implementation of rehabilitation plans. The replacement work will continue every year with the same pace for the whole period and complete by the year 2010.

Table 8.3-7 Quantities of Reinforcement and Construction of Overhead LT Feeders

			2000	2005	2010	Total
City	Reinforcement in the existing area	(km)	143	42	55	219
	Construction in the existing area	(km)	0	69	44	113
	Construction in new area	(km)	1	1	1	3
	Replacement to vinyl insulated conductor	(km)	1.9	9.5	9.5	21
Rural	Reinforcement in the existing area	(km)	158	58	96	288
	Construction in the existing area	(km)	0	95	75	170
	Construction in new area	(km)	10	27	30	67
	Replacement to vinyl insulated conductor	(km)	2	11	11	24

According to the result mentioned above, the required quantities of construction in each stage, i.e. for the year 2000, 2001 to 2005 and 2006 to 2010, are assumed to be constructed every year equally and the work quantities for three stage development are shown in the table 8.3-8.

Table 8.3-8 Volume of Low Tension Overhead Line Reinforcement and Construction

Company	Sub-project		2000-2002	2003-2005	2006-2010	Total
City	Reinforcement of LV Overhead Lines to 120AL	km	154.1	19.5	45.5	219.0
	Construction of LV Overhead Lines to 120AL	km	29.0	42.0	45.0	116.0
	Reinforcement of LV Overhead Lines to vinyl insulated conductor of 120AL	km	5.7	5.7	9.5	21.0
Rural	Reinforcement of LV Overhead Lines to 120AL	km	174.7	28.3	85.1	288.0
	Construction of LV Overhead Lines to 120AL	km	58.8	73.2	105.0	237.0
	Reinforcement of LV Overhead Lines to vinyl insulated conductor of 120AL	km	6.5	6.5	10.9	24.0

(3) Reinforcement and Construction of Underground LT Feeders

The ratio of loads delivered by underground feeders to all the low voltage loads is supposed to be 30% in Damascus City and 5% in Damascus Rural. For underground distribution network, types and cross section of cables even in the selected model area are not known to the Team. Most of the existing underground feeders are aligned in the radial form having concentrated loads at the end of feeder. The additional feeders are supposed to be constructed every year corresponding to the increase of power demand. The required number of additional feeder was obtained from increase of power demand divided by average load per feeder. The average peak current per feeder in the model area was 140 A which was adjusted for peak current in1998, and the average length of feeder was 100 m. Average peak current will remain unchanged through the period and the average length of feeder will decrease in inverse proportion to square root of power demand. The required quantity of reinforcement and construction is shown in the Table 8.3-9.

Table 8.3-9 Quantities of Construction of Underground LT Feeders

		2000	2005	2010	Total
Damascus City	(km)	30	32	35	97
Damascus Rural	(km)	4	12	15	31

According to the result mentioned above, the required quantities for the three stage development, i.e. for the year 2000, 2001 to 2005 and 2006 to 2010, are shown in the table 8.3-10.

Table 8.3-10 Volume of LT Underground Line Construction

Company	Project Name		2000-2002	2003-2005	2006-2010	Total
City	Construction of LV Underground Cables with 120C	(km)	43	19	35	97
Rural	Construction of LV Underground Cables with 120C	(km)	9	7	15	31

8.3.3 Low Voltage Service Wires/Cables, Meters and Aggregating Meter Boxes

(1) Construction of Low Voltage Service Wires/Cables

The quantity required for construction of low voltage service wires/cables to consumers was estimated, assuming that the number of consumer increases with the growth of power demand forecast as mentioned in chapter 4. The share of overhead service wire connections to consumers is estimated at 70 % for Damascus City and 95 % for Damascus Rural area, and the length of service connection is 5 m in average per consumer.

The required quantities of low tension service wires/cables construction for each period are estimated as shown in the able 8.3-11.

Table 8.3-11 Low Voltage Service Wires/Cables Construction

Company	Sub-project		2000-2002	2003-2005	2006-2010	Total
City	Construction of LV Overhead service wires	(km)	112.7	152.8	300.3	565.8
	Construction of LV Underground service cables	(km)	48.3	65.5	128.7	242.5
Rural	Construction of LV Overhead service wires	(km)	251.3	325.6	670.6	1,247.5
	Construction of LV Underground service cables	(km)	13.2	17.1	35.3	65.7

(2) Installation of Meters and Aggregating Meter Boxes

The number of meters required for new connections to consumers was estimated assuming that the number of consumers increases with the growth of power demand forecast. Meters required for replacement of the existing meters due to failure shall be included in the cost of operation and maintenance, and therefore not included in the improvement plans.

Aggregating meter boxes are to be installed only for new consumers, because of the difficulty to install at the existing consumers' building without repairing the building or relocation of the existing meters. One aggregating meter box shall accommodate five meters.

The required quantities of meters and aggregating meter boxes for each period of three stage development are estimated as shown in the Table 8.3-12.

Table 8.3-12 Quantities of Meters and Aggregating Meter Boxes (unit: pcs)

Company	Project Name		2000-2002	2003-2005	2006-2010	Total
City	Installation of meters	(x1,000)	32.2	43.7	85.8	162
	Installation of meter protection boxes	(x1,000)	6.4	8.7	17.2	32
Rural	Installation of meters	(x1,000)	52.9	68.6	141.2	263
	Installation of meter protection boxes	(x1,000)	10.6	13.7	28.2	53

8.3.4 Other Miscellaneous Works

(1) Repairing of the Existing Transformer Stations

As mentioned in Chapter 5, the Team found during the site investigation that some transformer stations need repairing due to inadequate installation of facilities. Through the result of the detail site investigation by the Team to the transformer stations in the selected model areas, work quantities of repairing required for all transformer stations in the study area are estimated.

Details of repairing works for the model areas and work quantities for whole study area are shown in the Table 8.3-13.

Table 8.3-13 Repairing of Transformer Stations

Item	Number to repair (in model area)			Number to repair (all study area)		
	City	Rural	Total	City	Rural	Total
Proper Installation of Underground Cables	6	22	28	378	793	1,171
Installation of Protective Pipes to Rising Cables	14	27	41	881	974	1,854
Providing Door Locks for Transformer Stations	6	3	9	378	108	486
Repairing of 20/0.4kV Transformer Stations	9	26	35	566	937	1,504
Repairing of LV Branch Boxes	7	21	28	440	757	1,198
Installation of LV Proper Fuses	15	32	47	944	1,154	2,098
Cleaning of 20/0.4kV Transformer Stations	22	29	51	1,384	1,046	2,430
Removal of Unnecessary Junk Equipment	20	25	45	1,258	901	2,160

All repairing works as mentioned in the above table shall be urgently necessary to complete by the end of year 2000 from the viewpoint of safety to personnel.

All the sub-projects mentioned in the Sections 8.2 and 8.3 required for rehabilitation and improvement of 20 kV and low voltage distribution facilities are listed for each period of implementation stage in the Attachment 8-2 (1), Attachment 8-2 (2) and Attachment 8-2 (3).

Table 8.1-2(1) Increase of Transformer Capacity

Damascus City Distribution Company

Name of Substations	Existing		2002								2005								2010							
	Transformer Capacity (MVA)	Total (MVA)	Peak Load (MW)	Peak Load (MVA)	Required Capacity (MVA)	Total (MVA)	10 MVA	20 MVA	30 MVA	40 MVA	Peak Load (MW)	Peak Load (MVA)	Required Capacity (MVA)	Total (MVA)	20 MVA	30 MVA	40 MVA	50 MVA	Peak Load (MW)	Peak Load (MVA)	Required Capacity (MVA)	Total (MVA)	20 MVA	30 MVA	40 MVA	50 MVA
1. Mazzrha	3 x 20	60	38	44	2x20+1x30	70		-1	1		46	54	2x20+1x30	70					64	75	3 x 30	90	-2	2		
2. Amaween	3 x 20	60	41	49	3 x 20	60					52	62	1x20+2x30	80	-2	2			78	92	3 x 40	120	-1	-2	3	
3. Mazzhe	3 x 20	60	30	35	3 x 20	60					35	41	3 x 20	60					47	56	1x20+2x30	80	-2	2		
4. Midan-1	3 x 20	60	30	35	3 x 20	60					33	39	3 x 20	60					41	48	1x20+2x30	80	-2	2		
5. Midan-2	1x20+2x30	80	65	76	4 x 30	120		-1	2		71	84	4 x 30	120					61	72	4 x 30	120				
6. Al Ashmar	2 x 20	40	38	45	2 x 40	80		-2		2	42	49	2 x 40	80					50	58	2x40+1x20	100	1			
7. Ersal	2 x 20	40	56	66	3 x 40	120					70	82	3 x 40	120					105	124	4 x 40	160			1	
8. Bab Sharki	3 x 20	60	27	32	3 x 20	60					32	38	3 x 20	60					42	49	3 x 20	60				
9. Qasr Al Shab	2 x 20	40	4	4	2 x 20	40					5	5	2 x 20	40					6	7	2 x 20	40				
10. Qaboon-1	3 x 40	120	55	65	3 x 40	120					64	75	3 x 40	120					82	96	3 x 40	120				
11. Qaboon-2	1x30+1x20	50	20	24	2 x 30	60		-1	1		22	26	2 x 30	60					28	33	2 x 30	60				
12. Al Hajer Al Aswa	2 x 30	60	31	36	2 x 30	60					25	29	2 x 30	60					31	36	2 x 30	60				
13. Al Jamha	2 x 20	40	18	21	2 x 20	40					21	24	2 x 20	40					27	32	2 x 30	60	-2	2		
14. Thawra	3 x 30	90	44	52	3 x 30	90					56	66	3 x 30	90					83	98	3 x 40	120		-3	3	
15. Dawar Al Matar	2 x 20	40	29	34	3 x 20	60		1			33	39	3 x 20	60					45	53	1x20+2x30	80	-2	2		
16. Dummar	2 x 20	40	43	51	3 x 20	60		1			48	56	3 x 30	90	-3	3			60	71	3 x 30	90				
17. Kafersuseh	2x30	60	39	46	2 x 30	60					44	52	2 x 50	100		-2		2	53	62	2 x 50	100				
18. Harash	2 x 30	60	37	44	2 x 30	60					45	53	2 x 50	100		-2		2	66	78	2 x 50	100				
19. Barzeh			12	14	2 x 30	60					14	16	2 x 30	60					18	21	2 x 30	60				
20. Jalaa			20	24	2 x 30	60					23	27	2 x 30	60					31	36	2 x 30	60				
21. Sh. Hasan			18	21	2 x 30	60					20	24	2 x 30	60					25	29	2 x 30	60				
22. Osoor			29	34	2 x 30	60					35	41	2 x 30	60					48	56	2 x 50	100		-2		2
23. Zablatani			38	45	2 x 30	60					44	52	2 x 50	100		-2		2	57	67	2 x 50	100				
24. Hosh Blas			31	36	2 x 30	60					35	41	2 x 30	60					42	49	2 x 40	80		-2	2	
25. Ibn Al Nafis			15	18	2 x 30	60					18	21	2 x 30	60					26	31	2 x 30	60				
Total		1060	807	949		1,700	0	-3	4	2	933	1,097		1,870	-5	-1	0	6	1,215	1,430		2,160	-10	1	9	2

Table 8.1-2(2) Increase of Transformer Capacity

Damascus Rural Distribution Company

Name of Substations	Existing		2002								2005								2010							
	Transformer Capacity (MVA)	Total (MVA)	Peak Load (MW)	Peak Load (MVA)	Required Capacity (MVA)	Total (MVA)	10 MVA	20 MVA	30 MVA	40 MVA	Peak Load (MW)	Peak Load (MVA)	Required Capacity (MVA)	Total (MVA)	20 MVA	30 MVA	40 MVA	50 MVA	Peak Load (MW)	Peak Load (MVA)	Required Capacity (MVA)	Total (MVA)	20 MVA	30 MVA	40 MVA	50 MVA
1. Duma	1x30+1x20	50	54	64	3 x 30	90		-1	2		68	80	3 x 30	90					67	79	4 x 30	120		1		
2. Adra-1	2x20+1x10	50	53	62	1x20+2x30	80	-1	-1	2		65	76	1x20+3x30	110		1			77	91	1x20+3x30	110				
3. Adra-2	1 x 20	20	35	41	3 x 20	60		2			45	53	3 x 20	60					36	42	3 x 20	60				
4. Kotaifa	1 x 10	10	12	14	1 x 20	20	-1	1			16	19	2 x 20	40	1				23	27	2 x 20	40				
5. Nabek	2 x 20	40	38	45	2 x 20+1x30	70			1		49	58	2 x 20+1x30	70					44	52	2 x 20+1x30	70				
6. Al Hameh	2 x 20	40	47	55	3x30	90		-2	3		59	69	3 x 30	90					69	81	4 x 30	120		1		
7. Sydanaya	2 x 20	40	27	32	2 x 20	40					34	40	2 x 20+1x30	70		1			40	47	2 x 20+1x30	70				
8. Zabadani	2 x 20	40	39	46	2 x 30	60		-2	2		35	41	2 x 30	60					52	61	3 x 30	90		1		
9. Fursan	2 x 30	60	51	60	3 x 30	90			1		43	51	3 x 30	90					52	61	3 x 30	90				
10. Al Matar	2x5+1x20	30	29	34	2x5+1x20+1x3(	60			1		35	41	2x5+1x20+1x3(	60					39	46	2x5+2x30	70	-1	1		
11. Izaa	2 x 20	40	25	29	3 x 20	60		1			29	34	3 x 20	60					29	34	3 x 20	60				
12. Moatamrat Palace	2 x 10	20	3	4	2 x 10	20					4	5	2 x 10	20					6	7	2 x 10	20				
13. Adra Cement	3 x 20	60	20	24	3 x 20	60					19	22	3 x 20	60					18	21	3 x 20	60				
14. Kisweh	2 x 20	40	32	38	2 x 20+1x30	70			1		37	44	2 x 20+1x30	70					53	62	3 x 30	90	-2	2		
15. Al Maarad	2 x 20	40	73	86	3 x 40	120			-2	3	70	82	3 x 40	120					86	101	3 x 40	120				
16. Dimas	1 x 20	20	14	16	2 x 20	40		1			16	19	2 x 20	40					23	27	2 x 20	40				
17. Nasrieh	1 x 40	40	16	19	1 x 40	40					20	24	1 x 40	40					28	33	1 x 40	40				
18. Kudseia	1 x 10	10	19	22	2 x 20	40	-1	2			23	27	2 x 20	40					0	0		0	-2			
19. Erbeen	2 x 20	40	38	45	3 x 20	60		1			48	56	1x20+2x30	80	-2	2			59	69	3 x 30	90	-1	1		
20. Al Faihaa	2 x 20	40	29	34	3 x 20	60		1			38	45	3 x 20	60					44	52	3 x 20	60				
21. Khan Al Shih	1 x 20	20	15	18	2 x 20	40		1			19	22	2 x 20	40					29	34	3 x 20	60	1			
22. Jededat Artouz											22	26	2 x 30	60					31	36	2 x 30	60				
23. Yalda											22	26	2 x 30	60					29	34	2 x 30	60				
24. Bludan											15	18	2 x 30	60					22	26	2 x 30	60				
25. Jaramana			13	15	2 x 30	60					15	18	2 x 30	60					21	25	2 x 30	60				
26. Al Tal																			21	25	2 x 30	60				
27. Yabroud																			30	35	2 x 30	60				
28. Harasta																			39	46	3 x 30	90		1		
29. Nashabieh																			28	33	2 x 30	60				
30. Meleha																			10	12	2 x 30	60				
31. Saiedeh Zinab																					2 x 30	60				
32. Kudseia-I																			36	42	2 x 30	60				
33. Kudseia-II																			14	16	2 x 30	60				
34. Darea																			35	41	2 x 30	60		1		
Total		750	682	803		1330	-3	4	11	3	847	996		1610	-1	4	0	0	1190	1399		2290	-5	9	0	0
Grand Total		1,810	1,489	1,752		3030	-3	1	15	5	1779	2093		3480	-6	3	0	6	2405	2829		4450	-15	10	9	2

Table 8.1-4 Replacement Schedule of 20 kV Switchgear

Damascus City Distribution Company

Substation	Transformer Capacity (MVA)	20 kV Switchgear						Number of Switchgear			Improvement Plan			Remarks
		Incoming trans.	Outgoing feeder	Bus coupler	Bus section	Measur-ing	Station Trans.	Minimum Oil Type	SF6 or Vacuum	Total	Up to 2000	Up to 2005	Up to 2010	
1. Mazzrha	3 x 20	3	26	1	2			32		32		Complete replacement		
2. Amaween	3 x 20	3	24	1	2			25	5	30		25 CBs to be replaced.		Original CBs from Merin Gerin in 1964. 5 CBs were replaced with BBC units.
3. Mazzhe	3 x 20	3	21	1	2	2	2	10	17	10		10 CBs to be replaced.		Original CBs are Merin Gerin of 1965, 17 are SF6 type of BBC & ABB made.
4. Midan-1	3 x 20	3	23	1	2	2	1	28		28	28 CBs to be replaced.			
5. Midan-2	1x20+2x30	3	42		2	2		47		47	47 CBs to be replaced.			All CBs are VEM of 1978.
6. Al Ashmar	2 x 20	2	18		2			22		22	Complete replacement by GIS			All CBs are in bad condition.
7. Ersal	2 x 20	2	36	1	2	2	1				35 CBs to be replaced.			
8. Bab Sharki	3 x 20	3	26	1	2							Colmplete replacement		
9. Qasr Al Shab	2 x 20	2	14	1		2								
10. Qaboon-1	3 x 40	4	54	2	4	6		62		62	10 CBs to be replaced	52 CBs to be replaced		
11. Qaboon-2	1x30+1x20	2	18		2	2		18		18		18 CBs to be replaced.		
12. Al Hajer Al Aswad	2 x 30	2	18		1	2		25		25			Complete replacement	All CBs are Minimum oil type of 1985.
13. Al Jamha	2 x 20	2	18		1			21		21			Complete replacement	
14. Thawra	3 x 30	3	24		2	1		29		29	Complete replacement by GIS			
15. Dawar Al Matar	2 x 20	2	19		2	3			23	23				
16. Dummer	2 x 20	2	27	1	2			32		32			Complete replacement	
Total		43	427	10	31	24	4	351	45	379				

Damascus Rural Distribution Company

Substation	Transformer Capacity (MVA)	20 kV Switchgear						Number of Switchgear			Improvement Plan			Remarks
		Incoming trans.	Outgoing feeder	Bus coupler	Bus section	Measur-ing	Station Trans.	Minimum Oil Type	SF6 or Vacuum	Total	Up to 2000	Up to 2005	Up to 2010	
1. Duma	1x30+1x20	2	13		1	2		16		16	16 CBs to be replaced.			All CBs are from VEM of 1974 to 1976
2. Adra-1	2x20+1x10	3	11			2		8	6	14	8 CBs to be replaced.			6 CBs are SF6 type.
3. Adra-2	1 x 20	1	8		2	4		11		11	11 CBs to be replaced.			
4. Kotaifa	1 x 10	2	9		1	2		12		12		12 CBs to be replaced.		All CBs are from VEM of 1978.
5. Nabek	2 x 20	2	12		1			15		15		Complete replacement.		All CBs are from VEM of 1974 to 1977.
6. Al Hameh	2 x 20	2	11	1				14		14		Complete replacement.		5 CBs from VEM and & from BBC Swiss in 1958.
7. Sydanaya	2 x 20	2	10		1	2		13		13			Complete replacement.	All CBs are from VEM of 1978.
8. Zabadani	2 x 20	2	8		1	2		11		11			Complete replacement.	All CBs are from VEM of 1979.
9. Fursan	2 x 30	1	13		1	2		14		14			Complete replacement by GIS.	All CBs are from VEM of 1976 c 1985
10. Al Matar	2x5+1x30	1	9		1	1		10		10		Complete replacement.		11 CBs are from VEM of 1978.
11. Izaa	2 x 20	2	9		1	2		11		11			Complete replacement.	All CBs are from VEM of 1979
12. Moatamrat Palace	2 x 10													
13. Adra Cement	3 x 20													
14. Kisweh	2 x 20	2	12		2			14		14			Complete replacement.	All CBs from VEM of 1984
15. Al Maarad	2 x 30	2	10		1			12		12			Complete replacement by GIS	All CBs from VEM of 1989.
16. Dimas	1 x 20	1	5			1		6		6				
17. Nasrieh	1 x 40	1	9			1			11	11				
18. Kudseia	1 x 10	1	4			1		5		5				All CBs from VEM of 1975
19. Erbeen	2 x 20	2	8		1				11	11				All CBs from Merlin Gerin
20. Al Faihaa	2 x 20	2	11		1			21		21			Complete replacement	
Total		31	172	1	15	22	0	193	28	221				
Grand Total		74	599	11	46	46	4	544	73	600				

Table 8.2-2 Construction Schedule on 20 kV Main Lines of Overhead Feeders

66/20 kV SS	No.	Name	1997 Peak Load (A)	Sections 1 size	1 km	2 size	2 km	3 size	3 km	4 size	4 km	5 size	5 km	6 size	6 km	7 size	7 km
Zabadani	102	Madaja	165	C185AL	0.5	120AS	1.5	25C+C1?	0.6	C185AL	1.8	120AS	2.0	C120AS	0.1	120AS	1.1
Zabadani	103	Bloudan	210	C185AL	0.5	120AS	3.4	16C	4.6	50C	0.1	16C	0.4	OC	0.5	50AS	1.3
Zabadani	202	Barada	120	C185AL	0.5	120AS	3.8	70AS	5.3	50AS	0.8						
Zabadani	204	Zabadani	100	C185AL	0.5	120AS	4.8	50AS	1.7								
Zabadani	101	Rawdah	25	C120AL	0.3	70AS	8.9	C120AL	0.4								
Zabadani	203	Souk	90	C185AL	0.5	120AS	4.9	16C	10.6	C120AL	0.1						
Zabadani	201	Sarf Sehee	50	C185AL	0.4	120AS	3.6										
Nabek	106	Dair Atia	120	C120AL	0.2	70AS	9.4	70AS	38.8								
Nabek	201	Kara	95	C120AL	0.2	120AS	11.2										
Nabek	103	Yabroud 2	160	C120AL	0.2	120AS	10.0										
Nabek	205	Yabroud 1	120	C120AL	0.6	120AS	1.8	50AS	6.1								
Nabek	105	Jaboor	5	C120AL	0.2	120AS	7.58	C120AL	0.5								
Nabek	101	Nasreia	5	C120AL	0.1	120AS	17.2										
Nabek	102	Mahloofa	90	C120AL	0.2	120AS	13.3	50AS	13.0								
Dawar Al Matar	101	Kazzaz	130	C120AL	1.2	35AS	2.1										
Maarad	103	Makam	200	C120AL	1.8	120AS	3.5	50AS	2.8	16C	2.2						
Maarad	206	Khyata	10	C185AL	1.3	120AS	4.6	C185AL	0.3								
Maarad	202	Al Nour	300	C185AL	0.4	120AS	8.2	OC120A	0.6	16C	2.1	C120AL	0.4	50AS	1.8	16C	0.5
Maarad	101	Bait Sahem	150	C185AL	0.3	120AS	1.7	50AS	3.4								
Maarad	104	Dyabia	120	C185AL	0.1	120AS	3.3	50AS	2.3								
Maarad	201	Faresa	85	C120AL	1.8	120AS	3.5	50AS	0.4	C120AL	0.6	50AS	0.4	120AS	0.3		
Maarad	204	Al Rawda	120	C185AS	1.3	120AS	6.3										
Maarad	102	Shabba	5														
Maarad	203	Al Baidar	5														
Maarad	205	Happy Land	5														
Duma	101	Douma	150	C120AL	0.1	120AS	2.8	16C	2.0								
Duma	103	Morakabat	50	C120AL	0.1	120AS	1.0	OC120A	3.0	C120AL	0.1	35C	1.0	16C	0.1	50AS	1.1
Duma	203	Mesraba	150	C120AL	0.1	120AS	2.0	25C	3.3	16C	1.5	C120AL	0.1	16C	0.4	C120AL	0.4
Erbeen	101	Askalanee	80	C185AL	1.4	50AS	0.1	OC120	0.3	50AS	0.1	16C	0.4	C120AL	1.3	50AS	0.5
Erbeen	102	Tasabehjee	9	C185AL	0.4	OC120A	1.3	16C	0.3	C120AL	1.4						
Quaboon 1	201	Dabagal	100	C185AL	0.3	25C	5.0	OC120A	0.0	120AS	0.8	25C	0.9	35C	1.1		
Duma	105	Al Hossen	60	C120AL	0.3	120AS	3.6										
Duma	205	Abiniah	10	C120AL	0.3	120AS	4.2	50AS	1.1	C120AL	?						
Duma	102	Eben Seena	95	C120AL	0.1	120AS	2.9	16C	1.5	16C	2.0						
		Total	3,209 A														

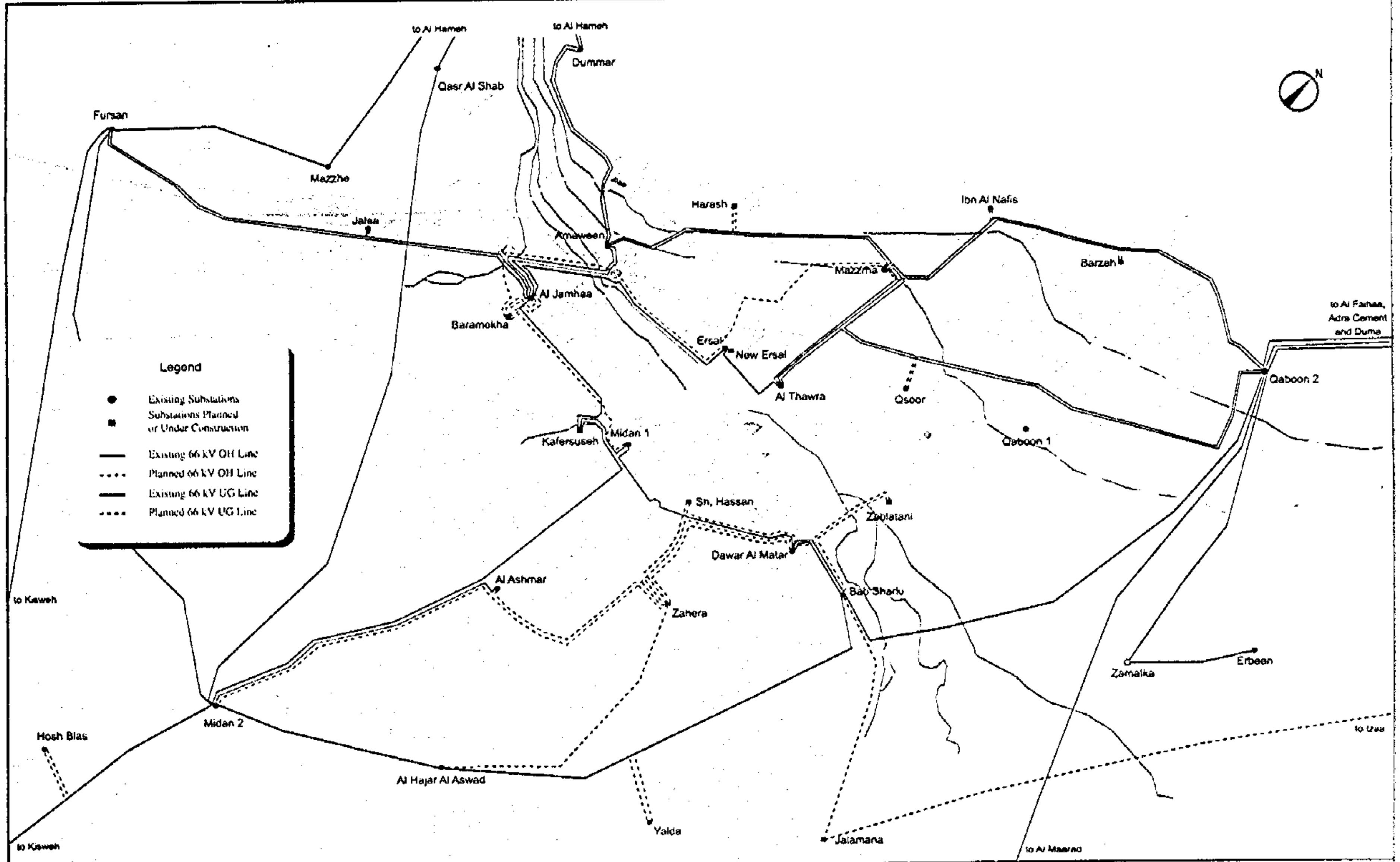
66/20 kV SS	No.	Name	8 size	8 km	9 size	9 km	10 size	10 km	11 size	11 km	12 size	12 km	13 size	13 km	Reinforcement of main lines O.H	U.G	O.C	Reinforcement of branches O.H	U.G	O.C	Construction of main lines O.H	U.G	O.C
Zabadani	102	Madaja													0	0.1	0						
Zabadani	103	Bloudan	C120AL	0.8											6.4	0.8	0.5						
Zabadani	202	Barada													6.1	0	0						
Zabadani	204	Zabadani													1.7	0	0	12.0	0.4	0.4	12.0	2.5	0.5
Zabadani	101	Rawdah													8.9	0.7	0						
Zabadani	203	Souk													10.6	0.1	0	9.0	0.3	0.3	11.0	1.5	0.3
Zabadani	201	Sarf Sehee																					
Nabek	106	Dair Atia													9.4	0.2	0						
Nabek	201	Kara													0	0	0						
Nabek	103	Yabroud 2													0	0.2	0						
Nabek	205	Yabroud 1													6.1	0.6	0						
Nabek	105	Jaboor													0	0.2	0	9	0.3	0.3	13	1.5	0.3
Nabek	101	Nasreia																					
Nabek	102	Mahloofa																					
Dawar Al Matar	101	Kazzaz													2.1	1.2	0						
Maarad	103	Makam													5.0	1.8	0						
Maarad	206	Khyata													0	0	0						
Maarad	202	Al Nour													4.3	0.4	0.6						
Maarad	101	Bait Sahem													3.4	0	0						
Maarad	104	Dyabia													2.3	0.0	0						
Maarad	201	Faresa													0.7	2.7	0						
Maarad	204	Al Rawda													0	0	0	36	1.2	1.2	38	6	1.2
Maarad	102	Shabba																					
Maarad	203	Al Baidar																					
Maarad	205	Happy Land																					
Duma	101	Douma													2.0	0.1	0						
Duma	103	Morakabat	OC120A	0.2	C120AL	0.4	50AS	0.5	C120AL	0.5					2.7	1.1	3.2						
Duma	203	Mesraba	16C	0.2	C120AL	0.6	16C	0.1	C120AL	0.1	16C	0.5	C120AL	1.0	6.0	2.3	0						
Erbeen	101	Askalanee	120AS	0.3	16C	1.2									2.3	1.3	0.3						
Erbeen	102	Tasabehjee													0.3	1.4	1.3						
Quaboon 1	201	Dabagal													6.9	0	0.0						
Duma	105	Al Hossen																					
Duma	205	Abiniah																					
Duma	102	Eben Seena													3.5	0.1	0	6.0	0.2	0.2	6.0	1.0	0.2
													Total		90.4	15.1	5.8	72.0	2.4	2.4	80.0	12.5	2.5
													Year 2005		71.0	14.3	5.7	30.0	1.0	1.0	34.0	5.5	1.1
													Year 2010		19.4	0.8	0.1	42.0	1.4	1.4	46.0	7	1.4

Rural Total 14,534 A

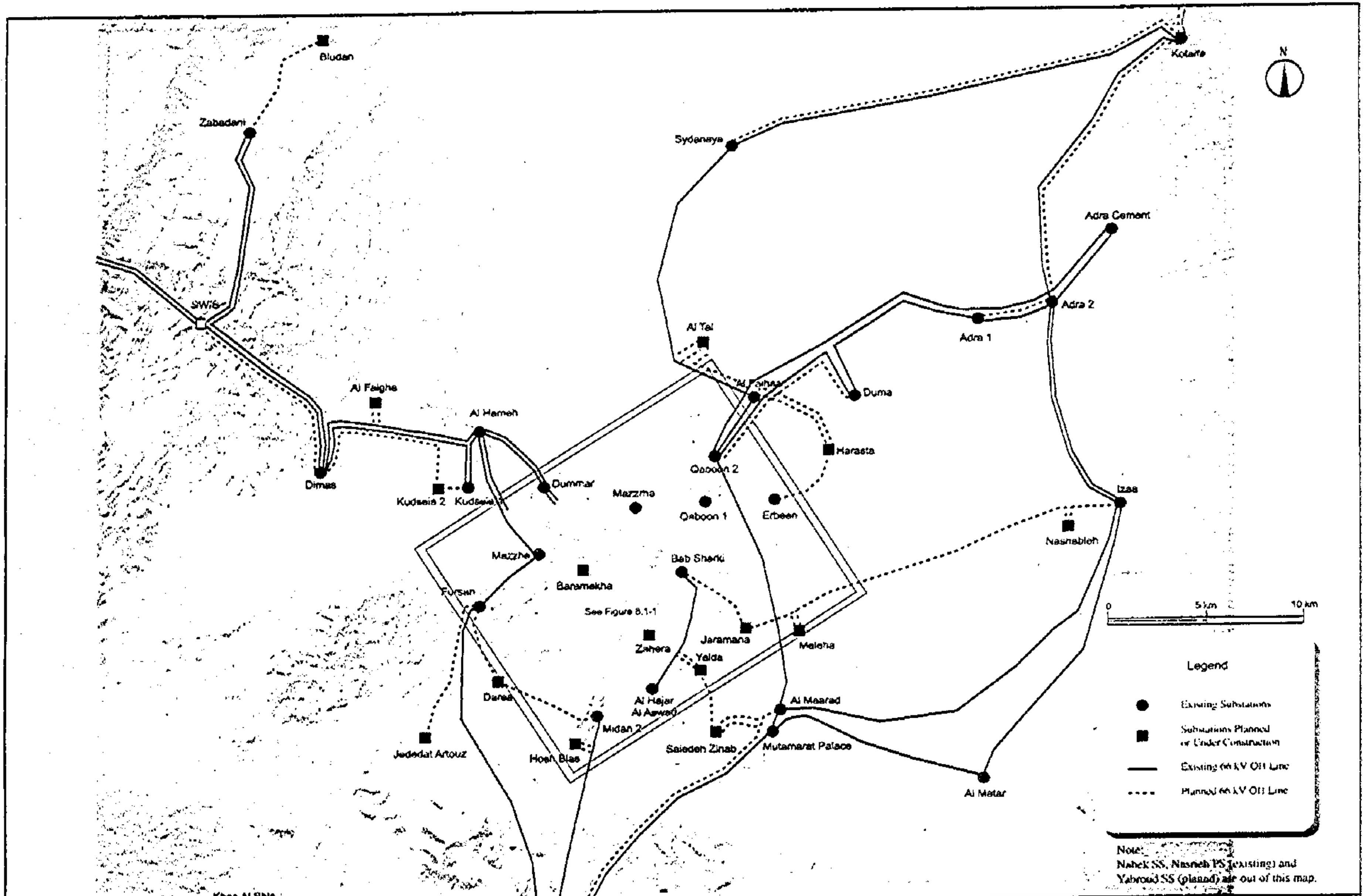
Estimated Rural Total Construction (km)

Rural	Reinforcement O.H	U.G	O.C	Reinforcement O.H	C	O.C	Construction O.H	C	O.C
Total	409.5	68.5	26.3	326.1	10.9	10.9	362.3	56.6	11.3
Year 2005	321.6	64.8	25.8	135.9	4.5	4.5	154.0	24.9	5.0
Year 2010	87.9	3.6	0.5	190.2	6.3	6.3	208.3	31.7	6.3

Rural	Reinforcement O.H.	U.G.C	O.H.C	Construction O.H.	U.G.C	O.H.C
Year 2005	457	69	30	154	25	5
Year 2010	278	10	7	208	32	6
Total	736	79	37	362	57	11

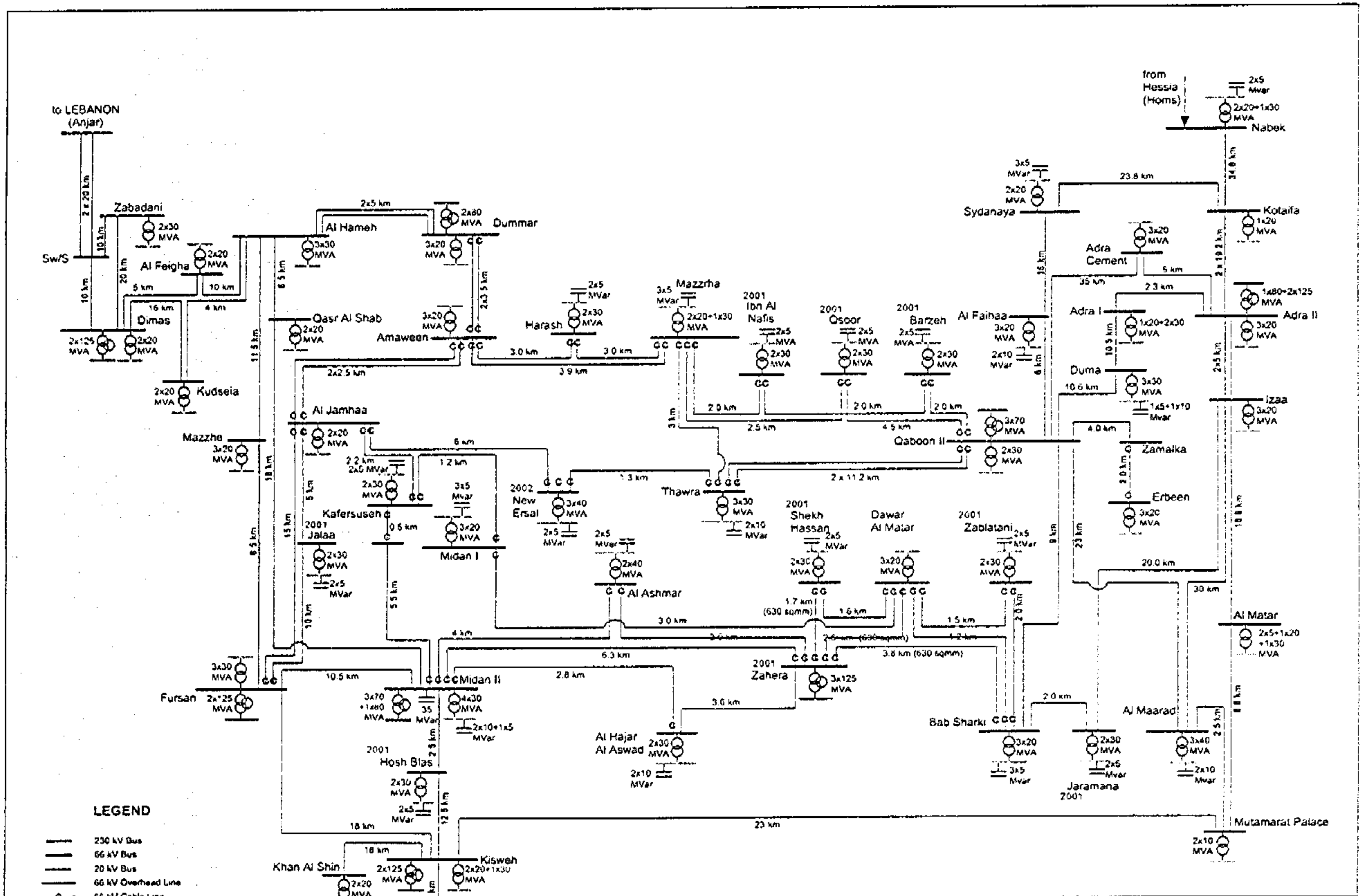


Public Establishment for Distribution Exploitation of Electrical Energy (PEDEEE)	Japan International Cooperation Agency (JICA) / Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Services Co., Ltd.	The Feasibility Study on The Rehabilitation Project of Damascus and Damascus Rural Distribution Network	Figure 8.1-1 Title Impovement Plan for 66kV System in Dmascus City

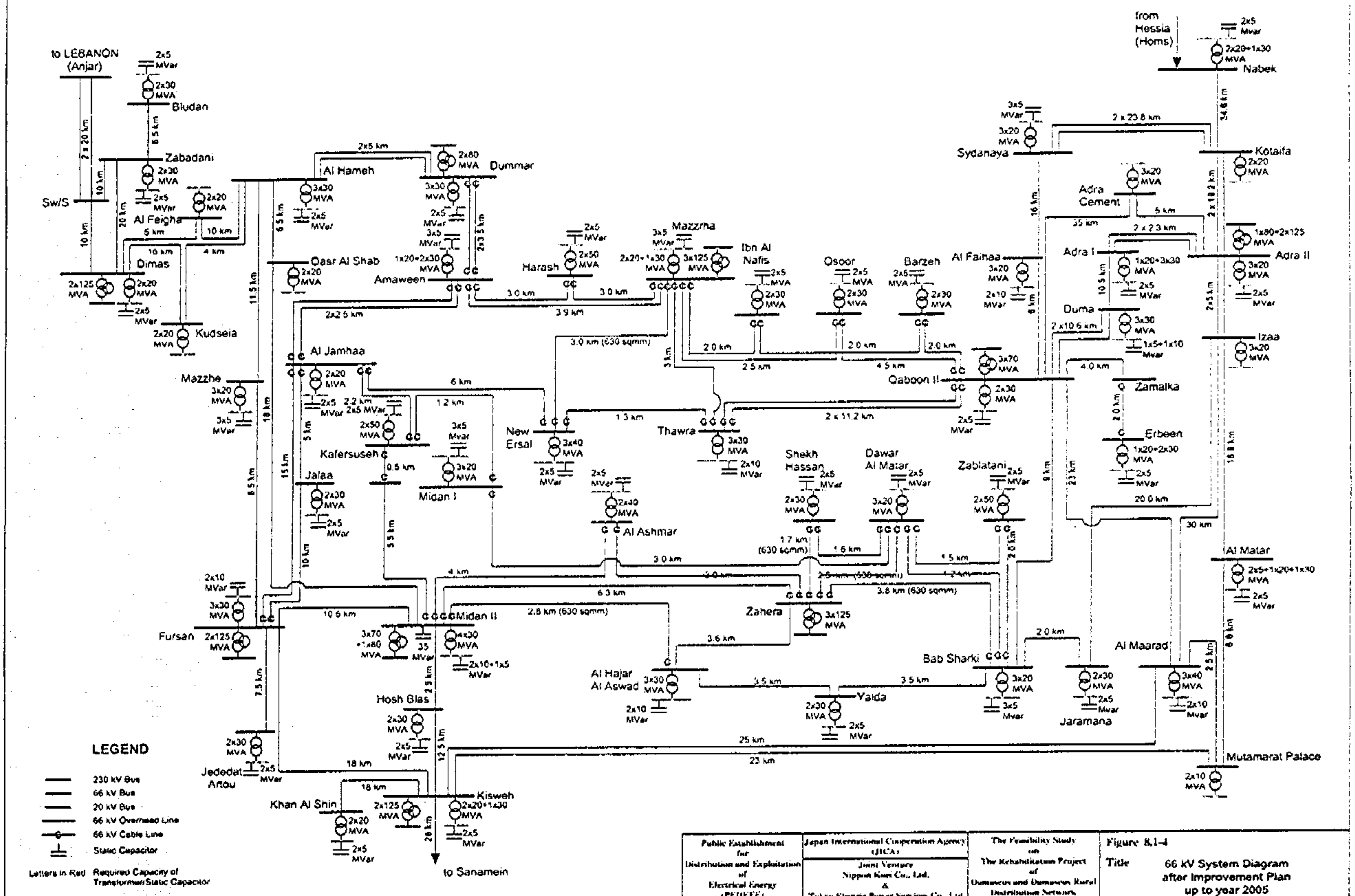


Note:
Nabek SS, Nasneh PS (existing) and Yabroud SS (planed) are out of this map.

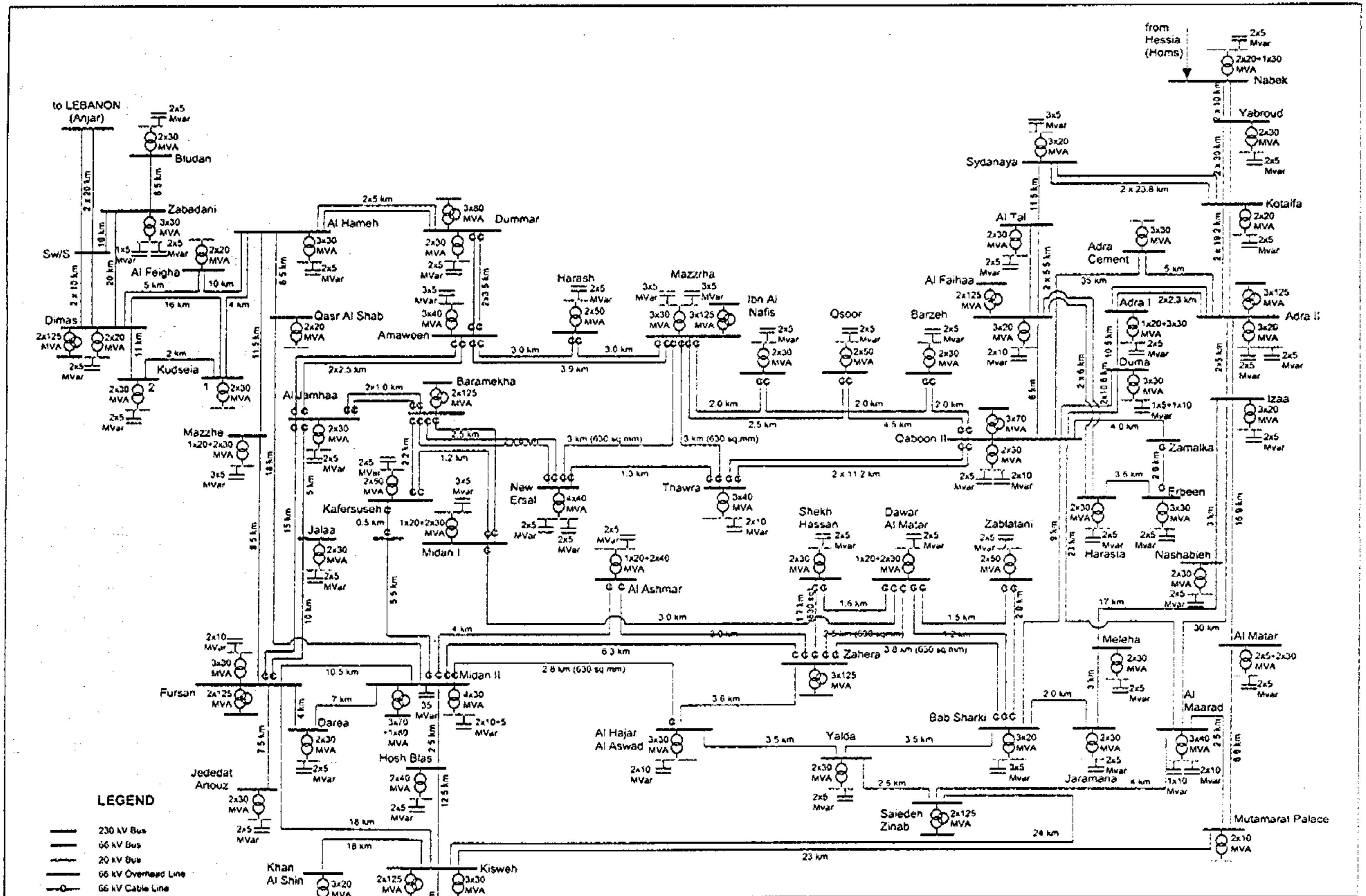
Public Establishment for Distribution Exploitation of Electrical Energy (PEDEEE)	Japan International Cooperation Agency (JICA) / Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Services Co., Ltd.	The Feasibility Study on The Rehabilitation Project of Damascus and Damascus Rural Distribution Network	Figure 8.1-2 Title: Improvement Plan for 66kV System in Damascus Rural



Public Establishment for Distribution and Exploitation of Electrical Energy (PEDEEE)	Japan International Cooperation Agency (JICA) / Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Services Co., Ltd.	The Feasibility Study on The Rehabilitation Project of Damascus and Damascus Rural Distribution Network	Figure 8.1-3 Title 66 kV System Diagram after Improvement Plan up to year 2002



Public Establishment for Distribution and Exploitation of Electrical Energy (PEDEEE)	Japan International Cooperation Agency (JICA) / Joint Venture Nippon Koei Co., Ltd. & Tokyo Electric Power Services Co., Ltd	The Feasibility Study on The Rehabilitation Project of Damascus and Damascus Rural Distribution Network	Figure 8.1-4 Title 66 kV System Diagram after Improvement Plan up to year 2005



Public Establishment for Distribution and Exploitation of Electrical Energy (PEDEEE)	Japan International Cooperation Agency (JICA) / Joint Venture of Nippon Koei Co., Ltd. & Tokyo Electric Power Services Co., Ltd.	The Feasibility Study on The Rehabilitation Project of Damascus and Damascus Rural Distribution Network	Figure 8.1-5 Title: 66 kV System Diagram after Improvement Plan up to year 2010