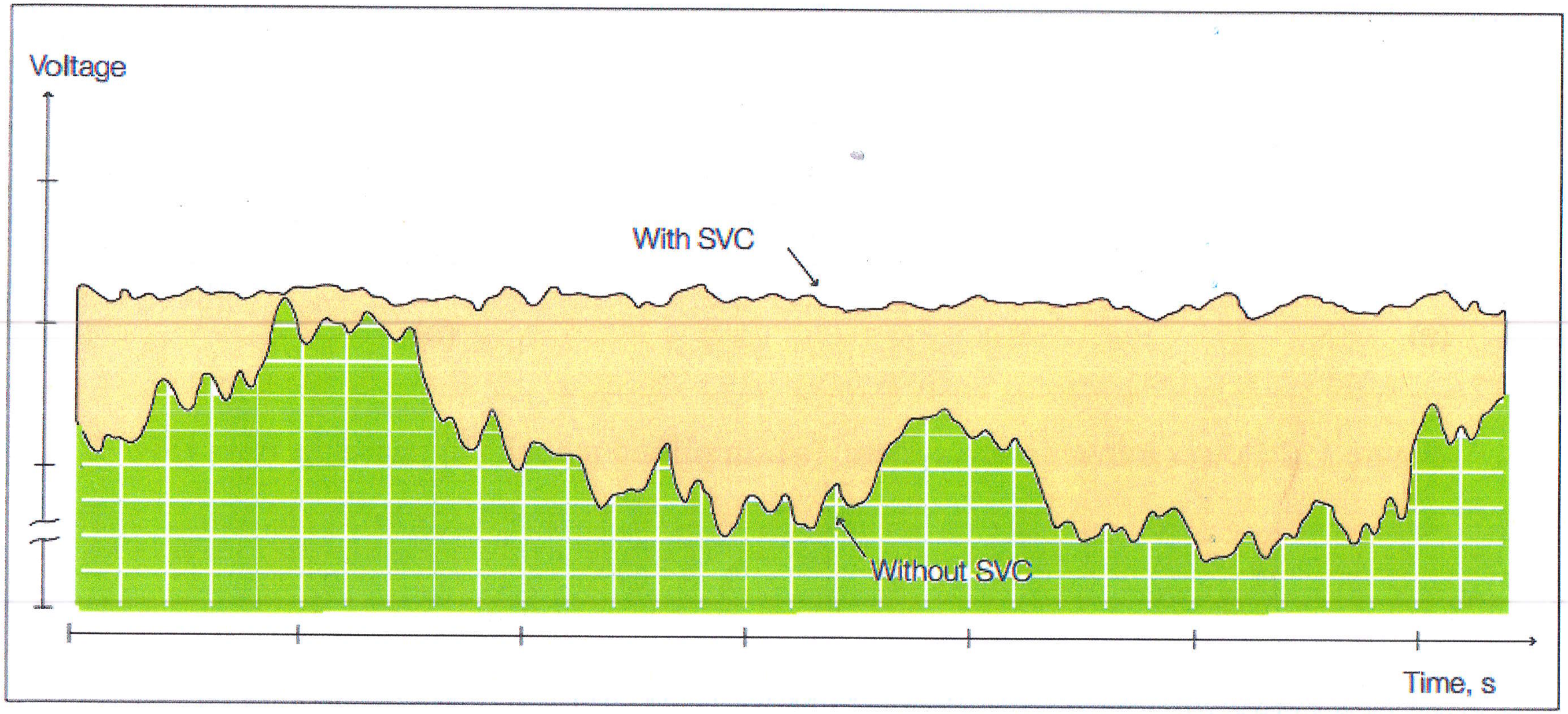
ئاوات على صالح

Voltage Control

(<u>**S**</u>tatic <u>**V**</u>ar <u>**C**</u>ompensator)

Define Static VAR Compensator:

IEEE defines Static VAR Compensator as a shunt connected static VAR generate or absorber whose output is adjusted to exchange capacitive or inductive power in order to control reactive power flow in power systems.



Power Transfer Theory :

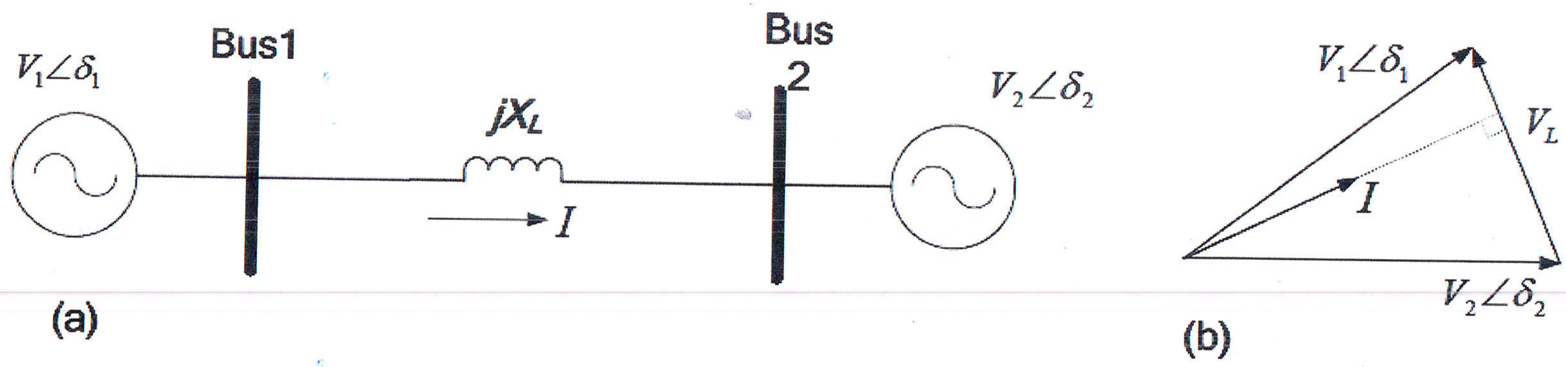


Figure 1. 1 Power transmission system: (a) simplified model; (b) phase diagram [5]

$$I_{d1} = \frac{V_2 \sin\delta}{X_L}, \qquad I_{q1} = \frac{V_1 - V_2 \cos\delta}{X_L} \qquad (1\text{-}2)$$

The active power and reactive power at bus 1 are given by:

$$P_1 = \frac{V_1 V_2 \sin\delta}{X_L}, \qquad Q_1 = \frac{V_1 (V_1 - V_2 \cos\delta)}{X_L} \qquad (1\text{-}3)$$

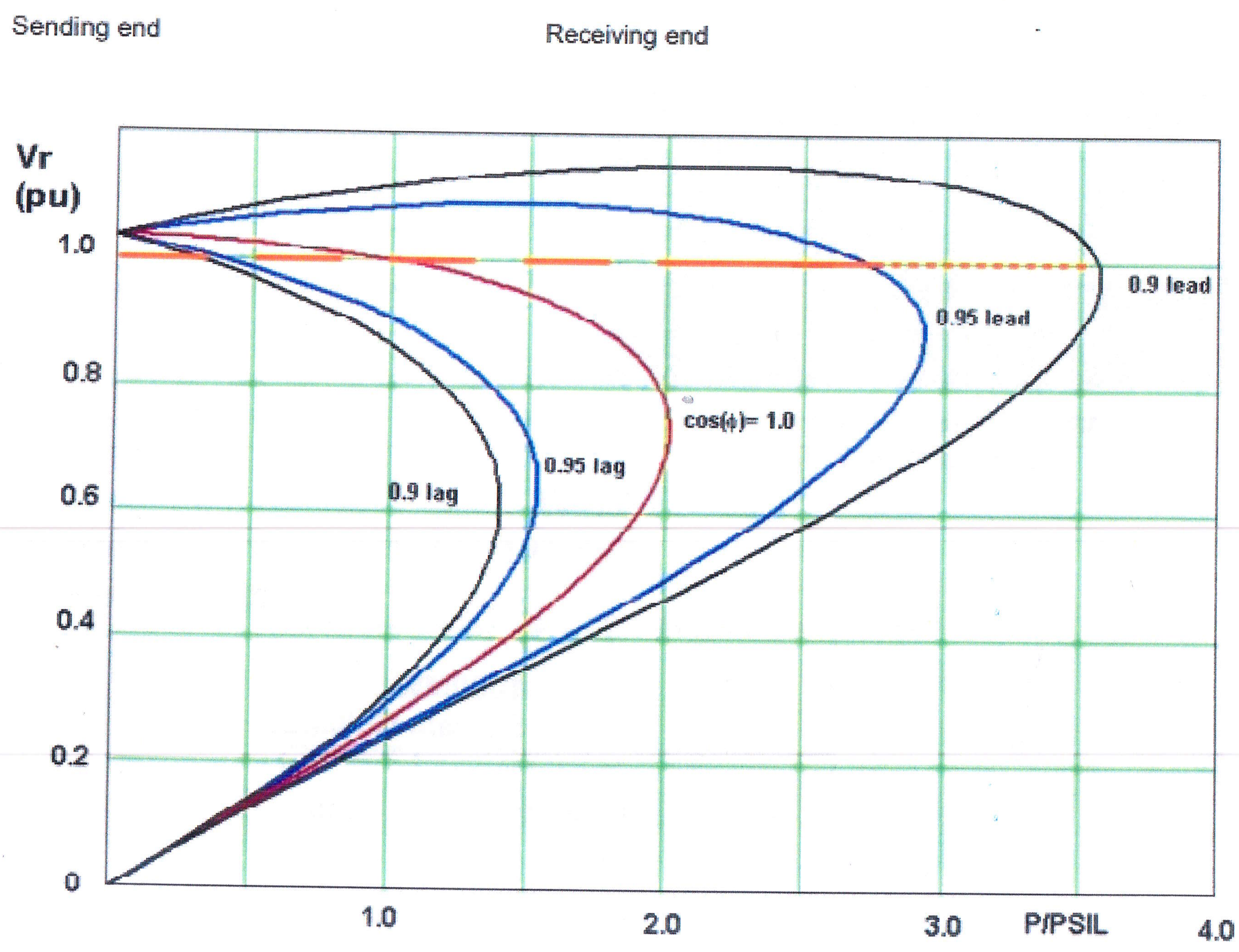
Similarly, the active and reactive components of the current flow at bus 2 can be given by:

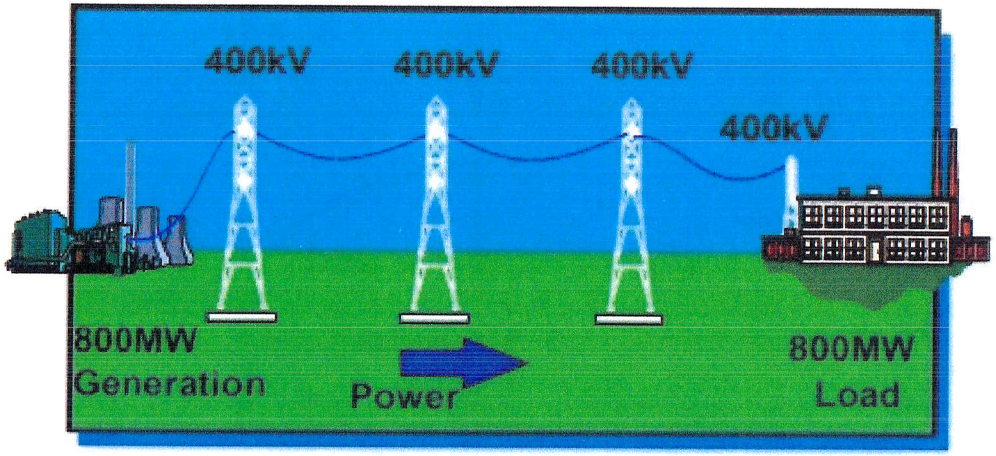
$$I_{d2} = \frac{V_1 \sin\delta}{X_L}, \qquad I_{q2} = \frac{V_2 - V_1 \cos\delta}{X_L} \qquad (1\text{-}4)$$

The active power and reactive power at bus 2 are given by:

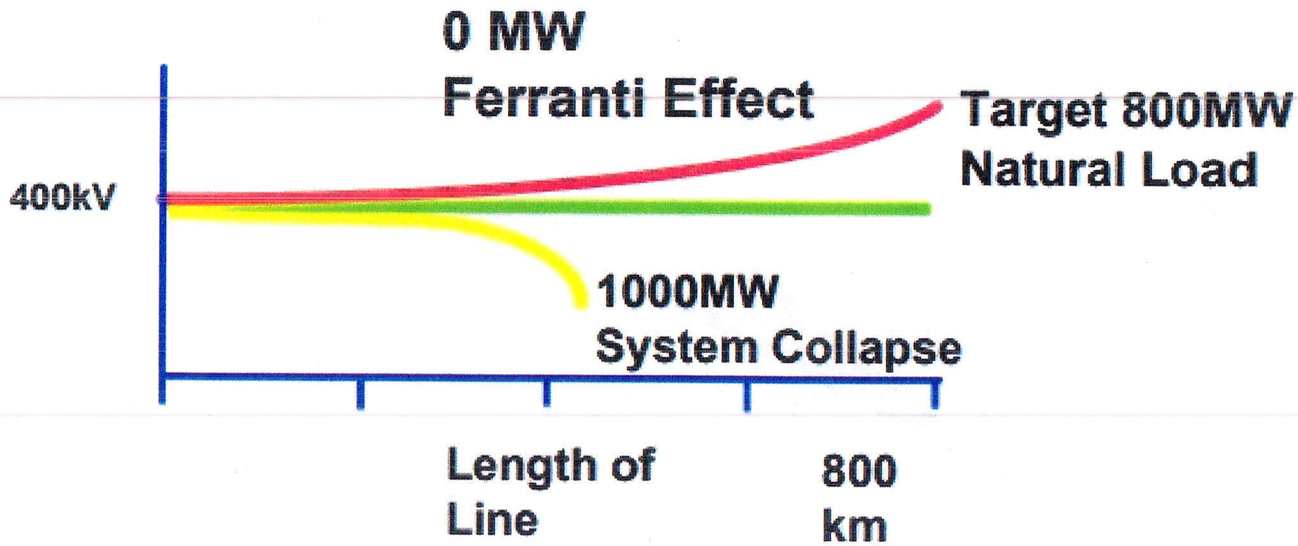
$$P_2 = \frac{V_1 V_2 \sin\delta}{X_L}, \qquad Q_2 = \frac{V_2 (V_2 - V_1 \cos\delta)}{X_L} \qquad (1\text{-}5)$$

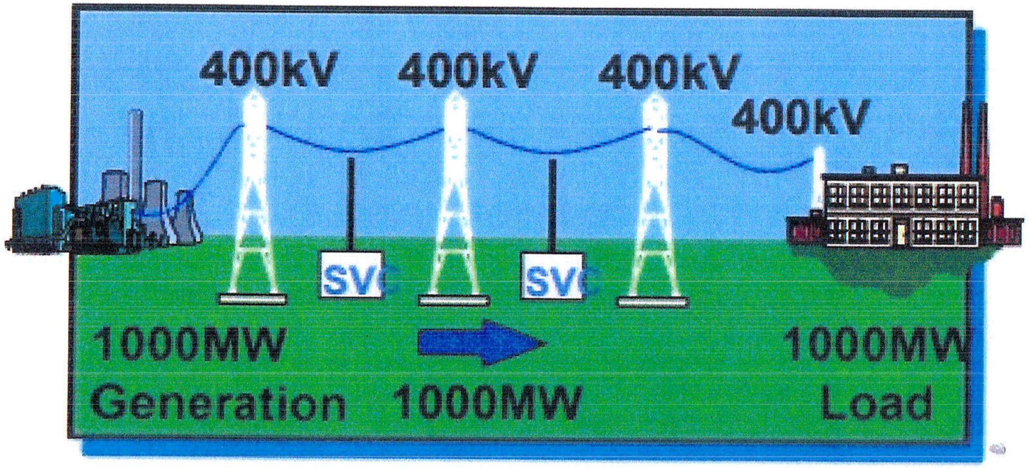
$$Q_2 = \frac{V_2(V_2 - V_1 \cos\delta)}{X_L}$$


Sending end
Receiving end
Vr
(pu)
1.0
0.8
0.6
0.4
0.2
0
1.0
2.0
3.0
P/PSIL
4.0
0.9 lead
0.95 lead
cos(ϕ)= 1.0
0.95 lag
0.9 lag



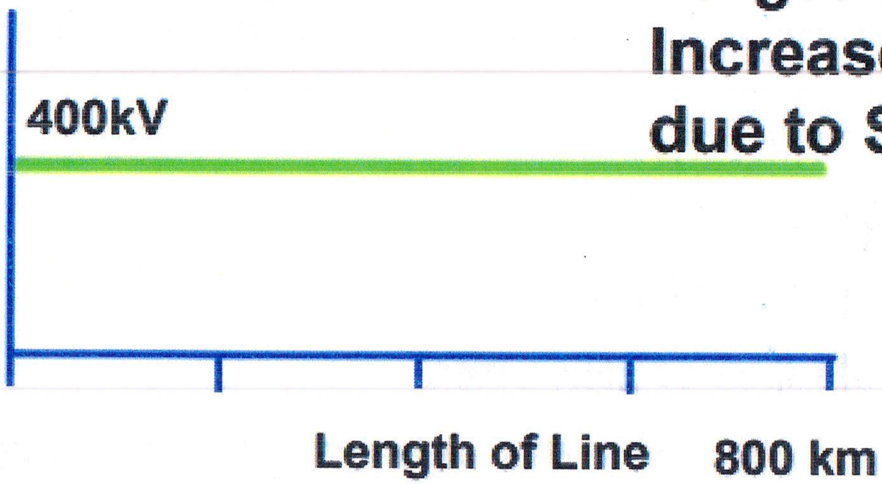
400kV Transmission Line
(uncompensated)





Shunt Compensated Line

Target 1000MW
Increased capacity
due to SVC



Advantage of VAR compensator

1-Control Power Follow.

2-Increasing distribution reliability.

3-Load balance.

4-Power Factor Correction (increase power quality).

5-Voltage Regulation.

6-Removing harmonics.

7-Increasing capacity of Power Transformers, Transmission Lines, Power Cables

8-Saving of Money.

9-Increase System Stability.

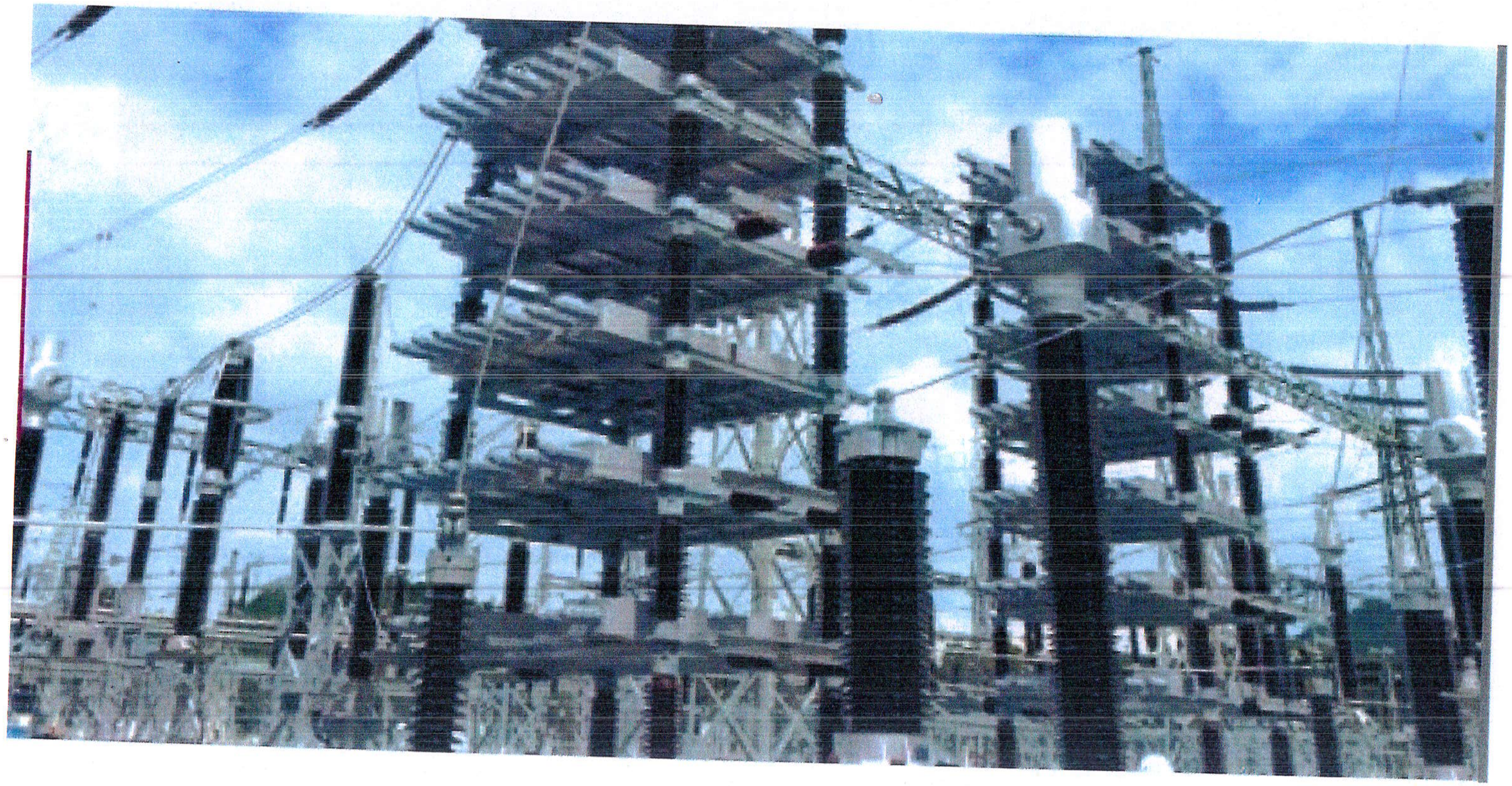
10-Remove voltage flicker.

11-Increase life span of generators.

12-Increase life span of transformer on load tap changer.

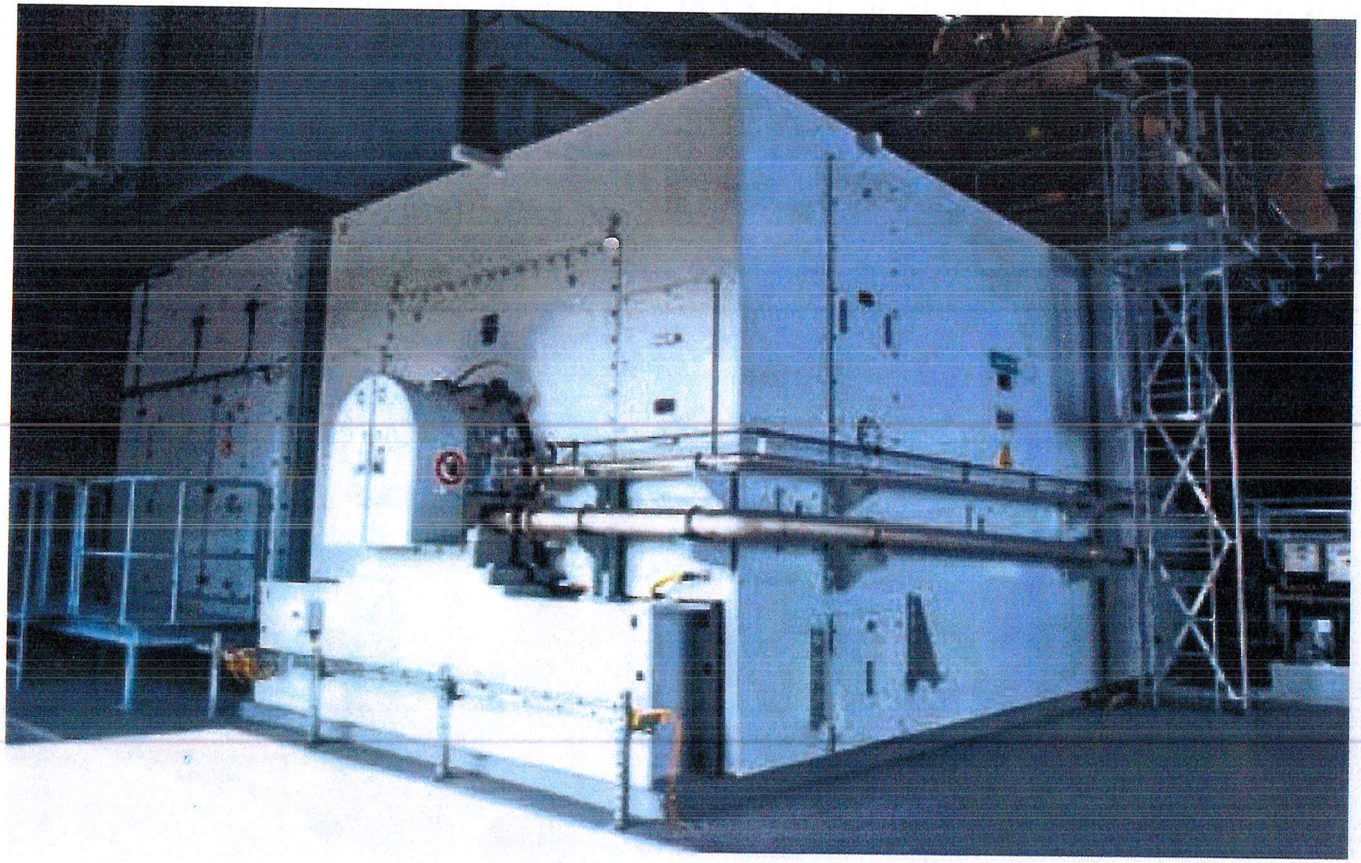
VAR Compensator Types

1-Mechanical Switching Capacitor and Reactor : Not use in KRG grid



VAR Compensator Types

2-Synchronous Condenser : synchronous generator and a field control circuitry



Direct air-cooled generator

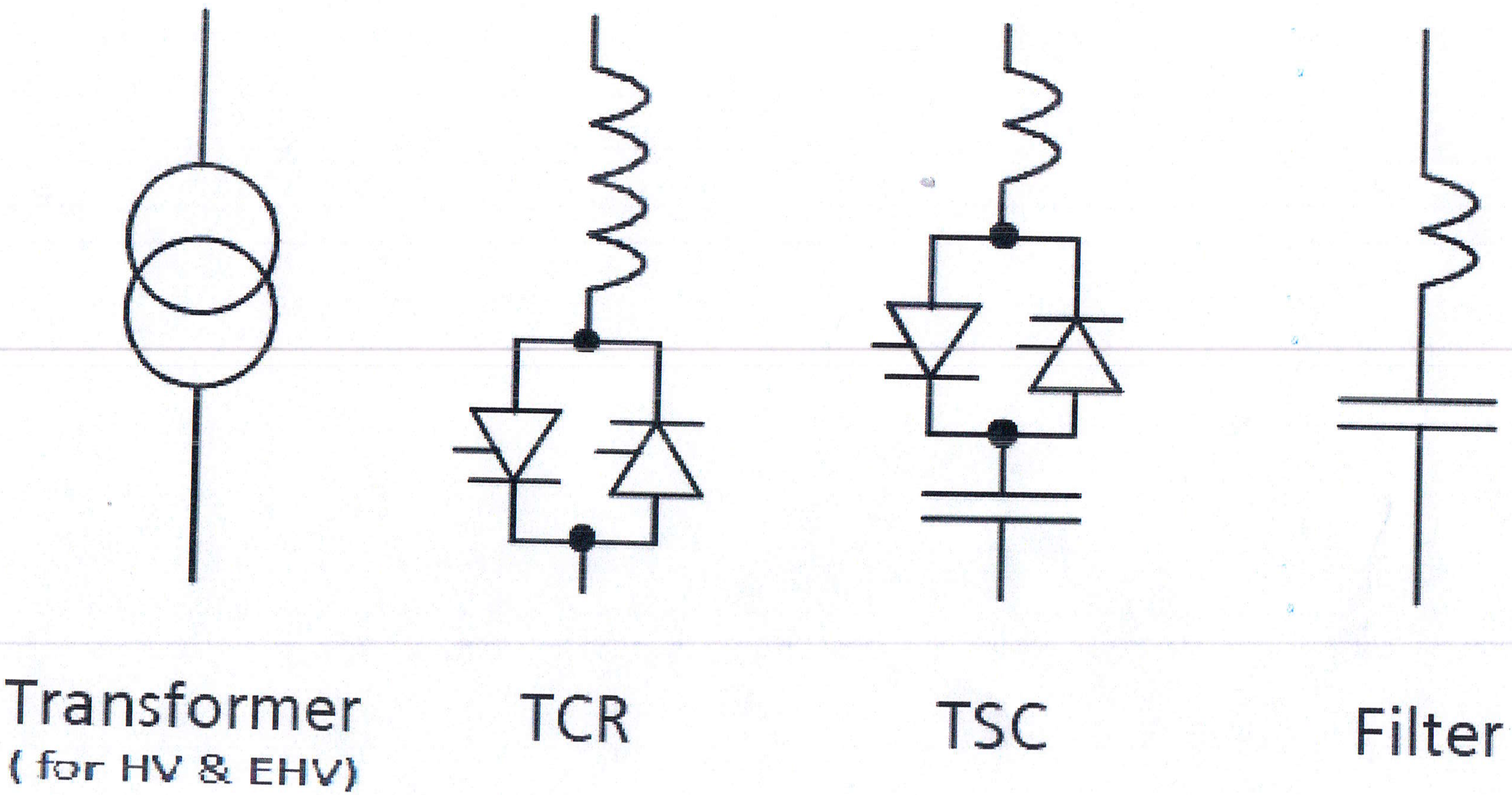
VAR Compensator Types

3-Static VAR Compensator (SVC) : Like used by POLTIX STEEL Factory- ERBIL

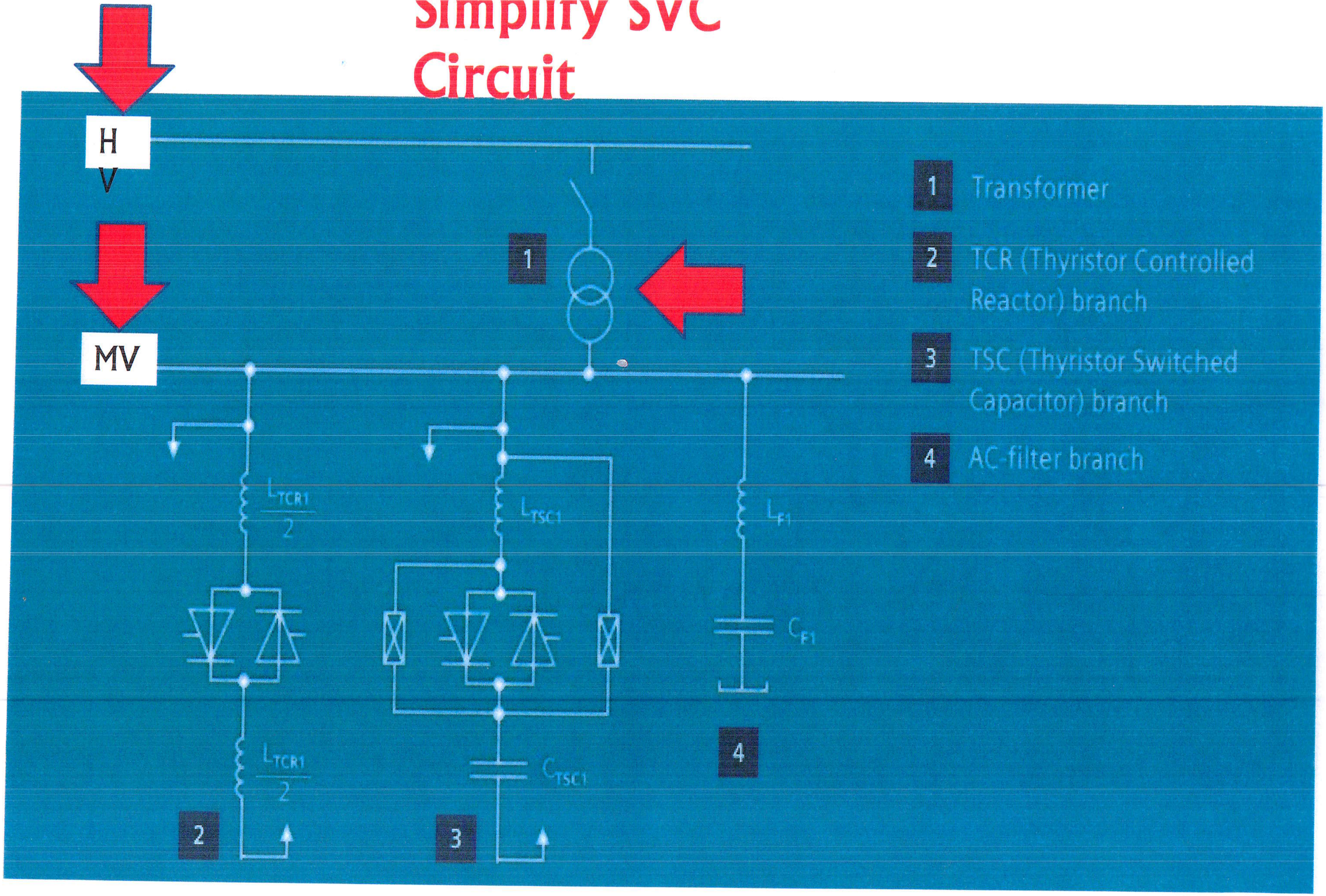
Comparing between VAR Compensator Types

No	Items	MSC MSR	Syncho Condenser	SVC
1	Fuel	No	Yes	No
2	Area	Very High	High	Low
3	Time Response	70-100 ms	> 100 ms	20 to 30 ms
4	Cost	High	High	Low
5	Operating Voltage	HV, MV	HV, MV	MV
6	Change in VAR	in step	in step	Linearly
7	Semiconductor	No	No	Yes
8	Maintenance	Easy	Not Easy	Easy
9	Cooling System	No	Yes	Yes

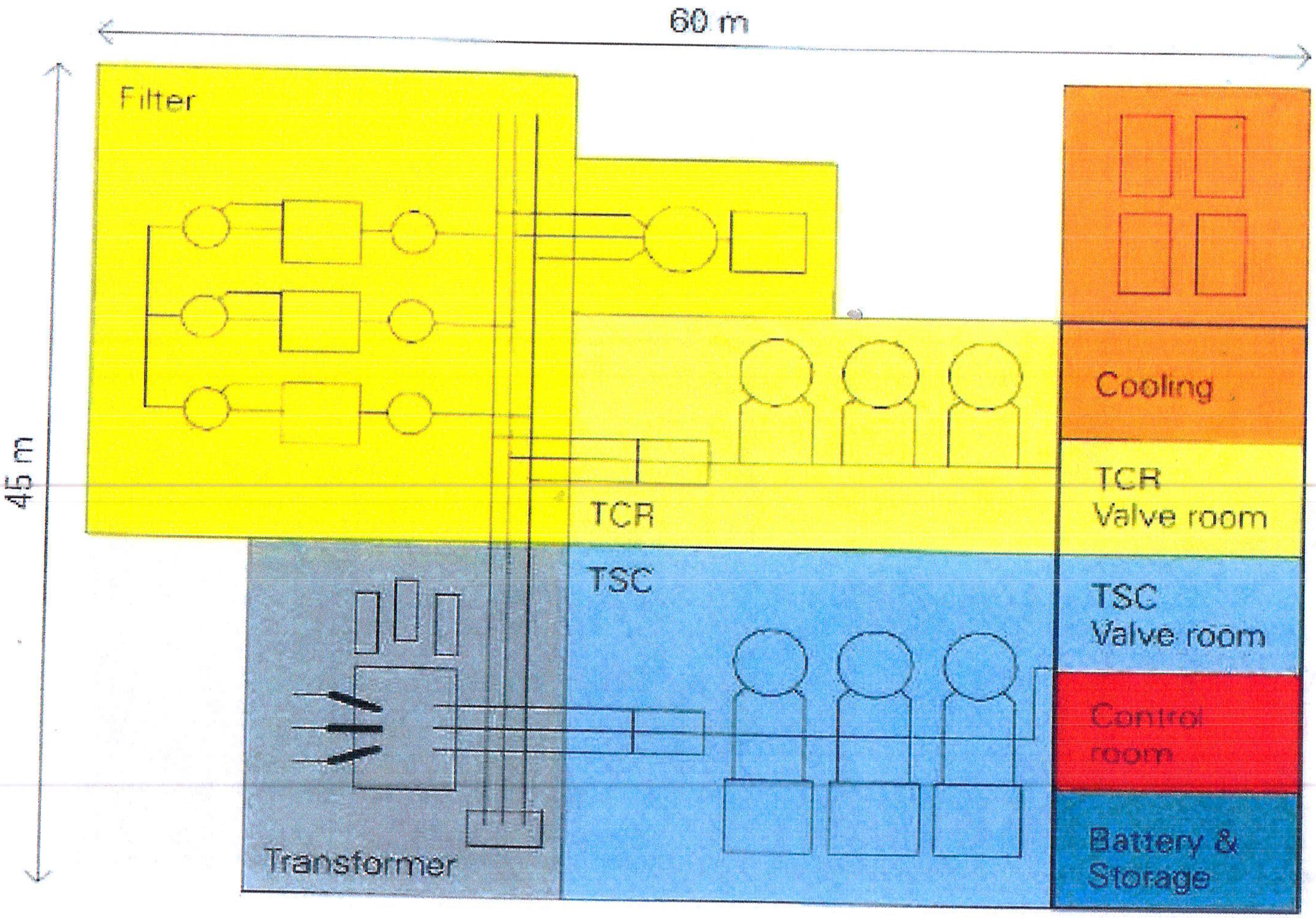
Static VAR Compensator Equipment



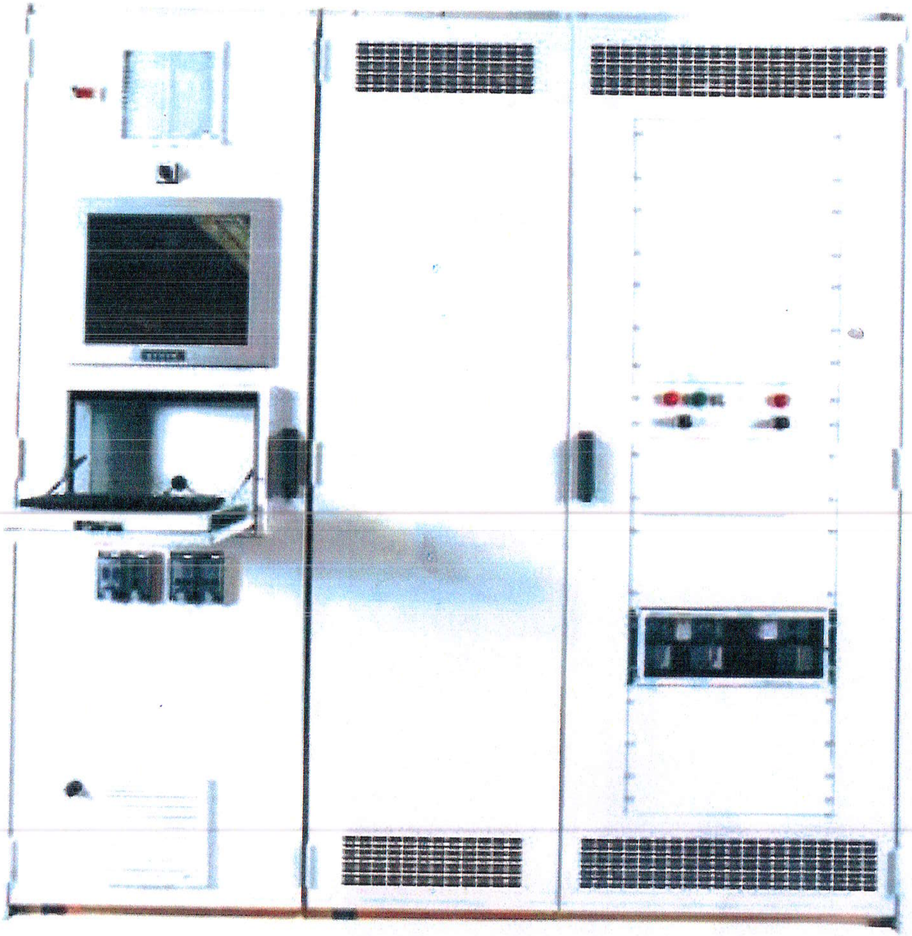
Simplify SVC Circuit



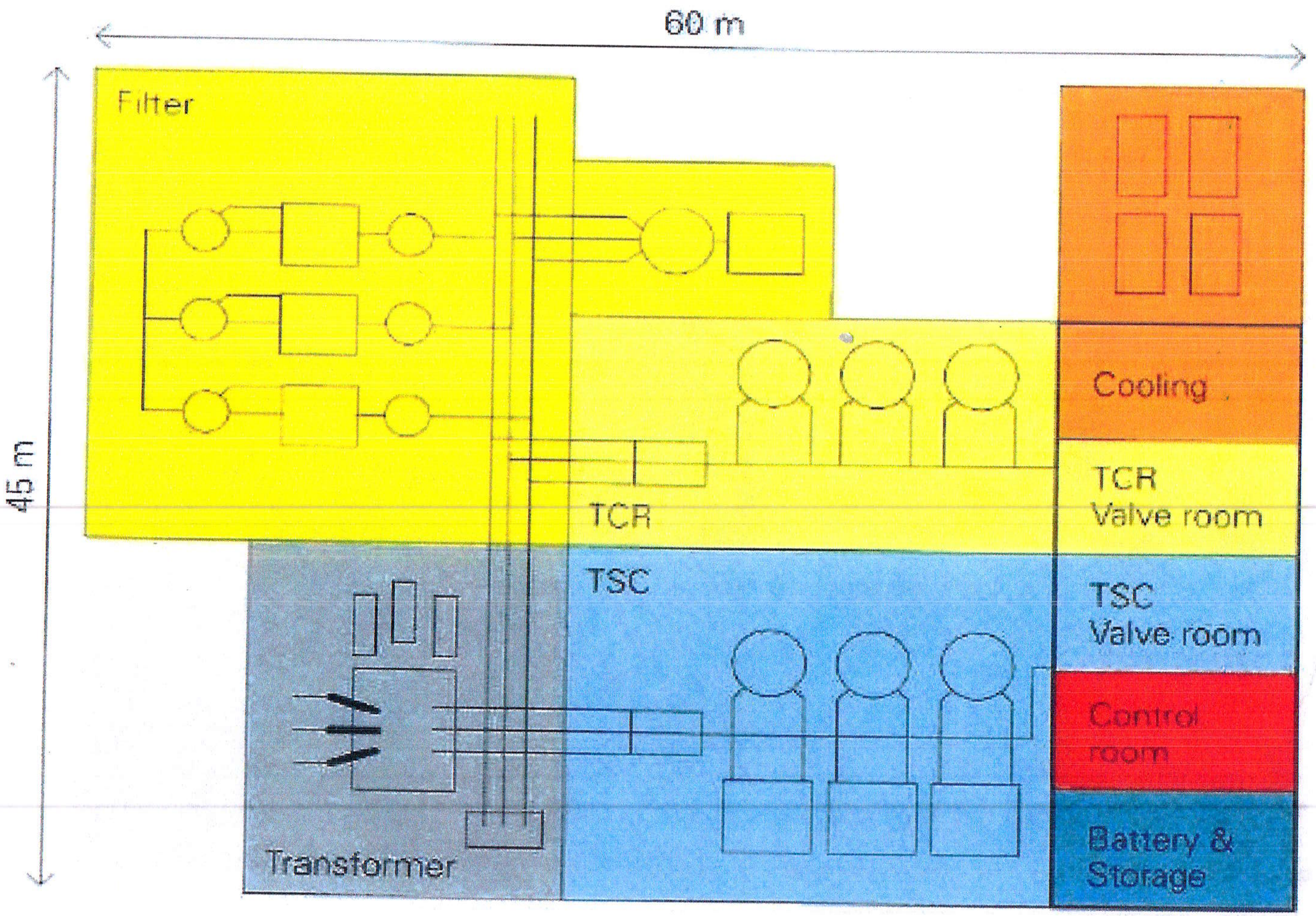
SVCs Centrals, NGC, UK 275 kV, 150 c / 75 i MVar



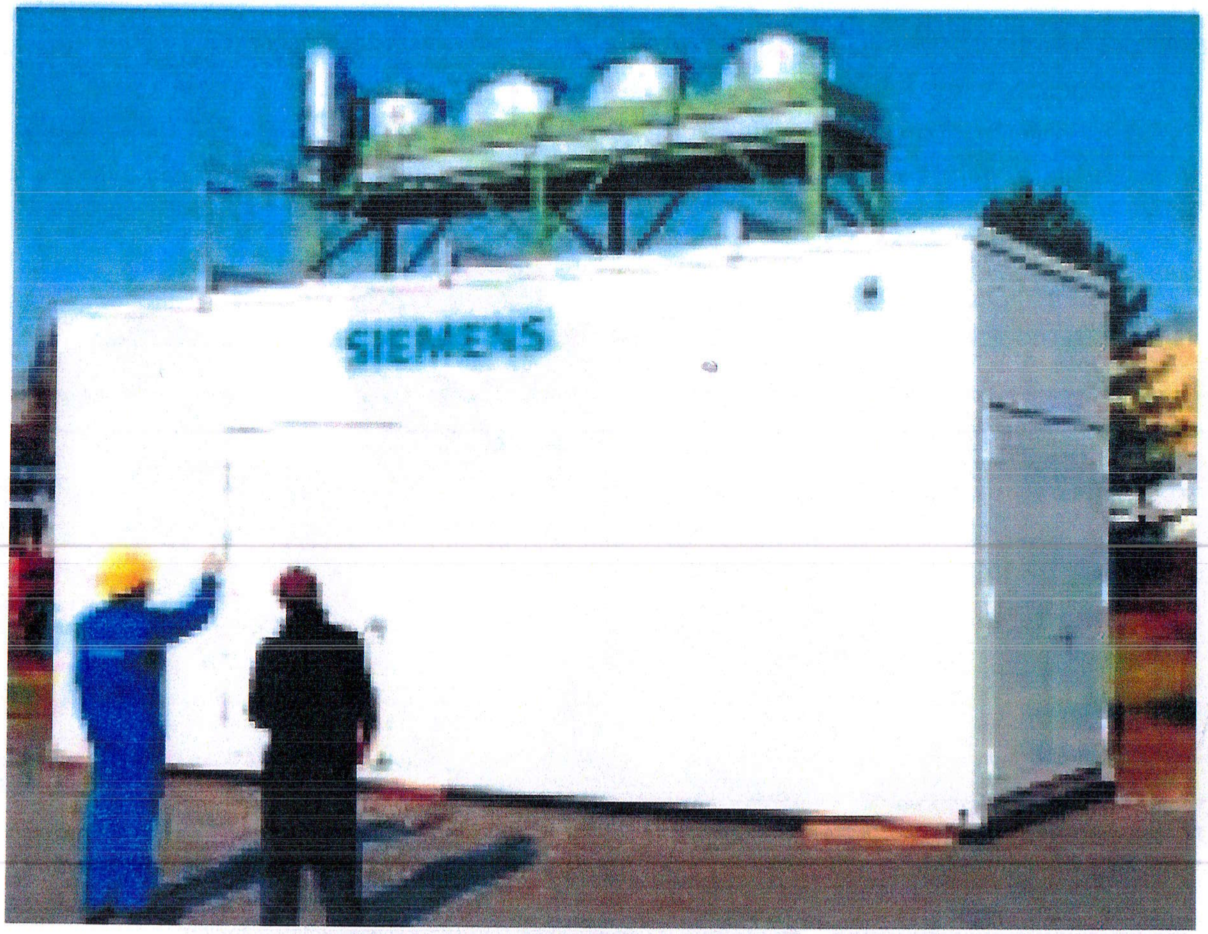
SVC Control and Protection



SVCs Centrals, NGC, UK 275 kV, 150 c / 75 i MVar



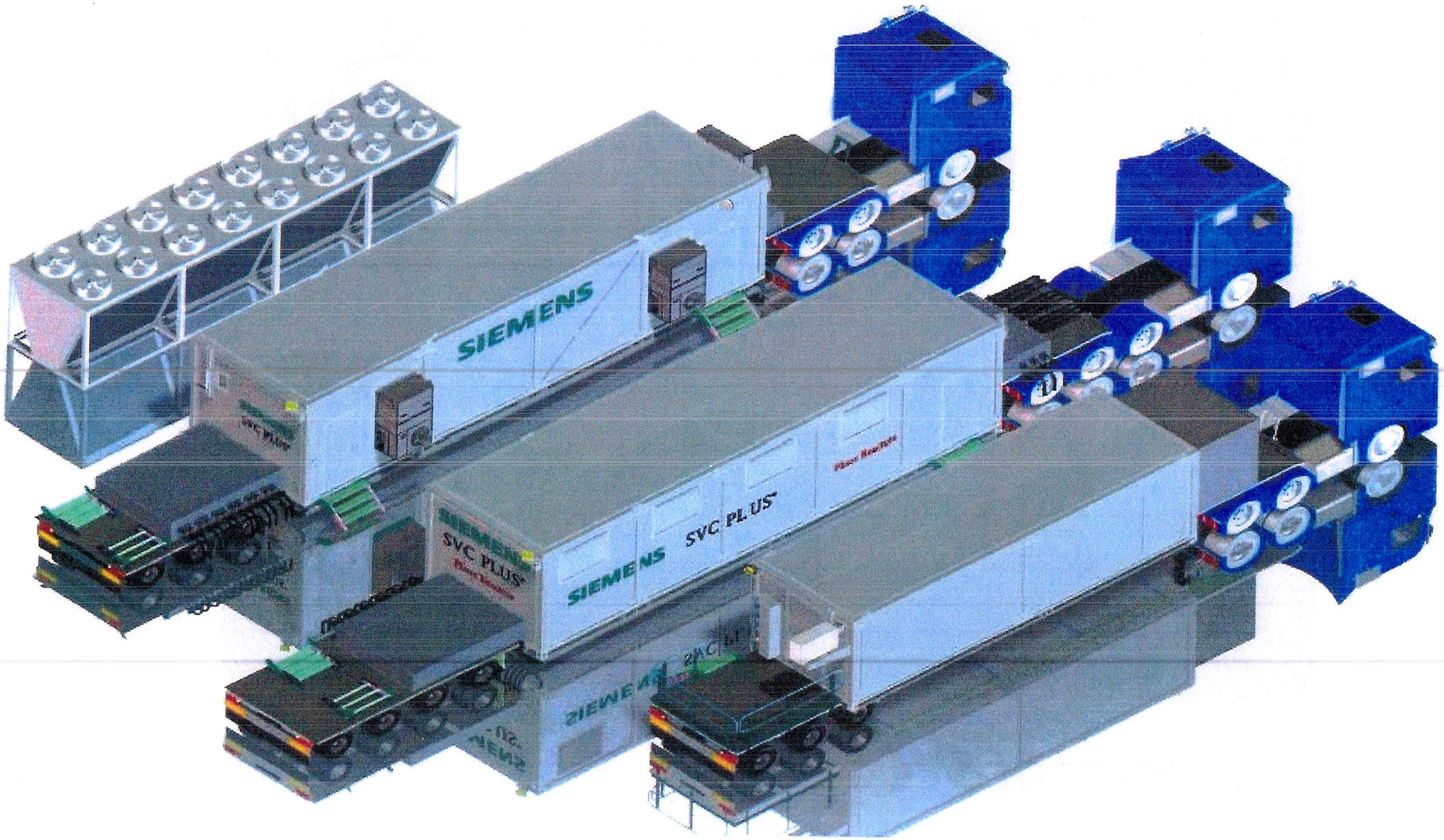
SVC in Container



Container of SVC Jember

STATCOM (for DC generation)

50 MVAR Mobile STATCOM 125 % Overload 2 Seconds



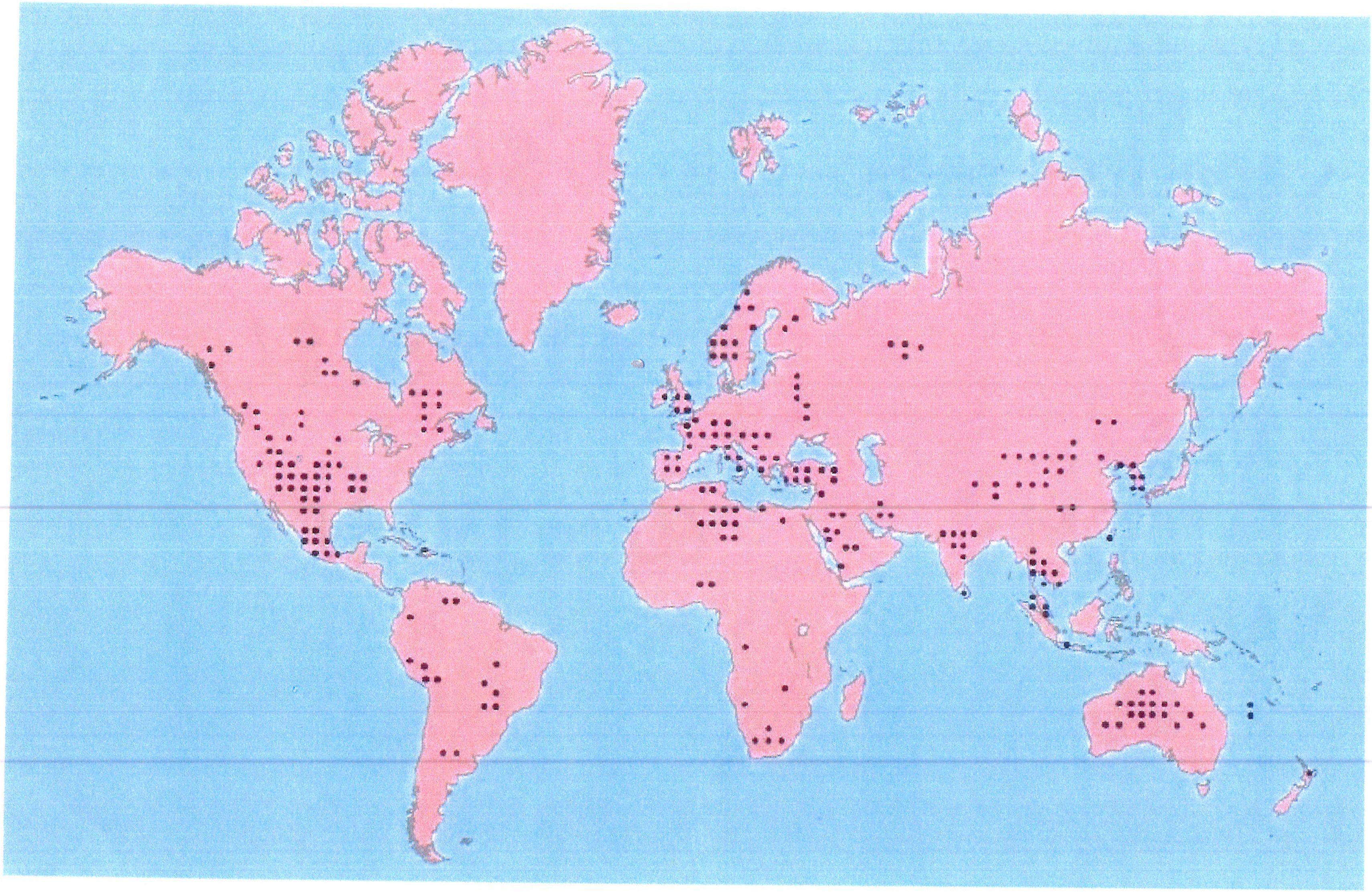
Price for SVC (2018)

Capacitor Bank: 2 to 10 $/ k VAR

SVC : 40 to 80 $/
k VAR

STATCOM : 60 to 130 $/ k
VAR

ABB Installed more than 500 SVC until 2018



Suggestions

1- Replace existing capacitor bank in substations by SVC

Calculations :

For ERBIL substations:

66 capacitor bank X 10MVAR = 660 MVAR
81 capacitor bank X 5MVAR = 405 MVAR
Total additional MVAR = 1,065 MVAR

2- Future new substations will install SVC instead of capacitor banks

Any questions ?

Thank You