LAUTECH Journal of Engineering and Technology 5(1) 2009:68 – 74

LOAD MANAGEMENT AUTOMATION FOR ELECTRIC POWER SYSTEM OPERATION CONTROL IN NIGERIA

A.A. Ayeni and D.A. Folarin

Department of Electrical Engineering, University of Ilorin, Ilorin, Kwara State
Electrical Electronics Department, Federal Polytechnic, Ede. Osun State

ABSTRACT

This research work is borne out of the interest to examine whether poor system operation control is what is responsible for power instability in Nigeria. The author researched into the system operation control of the Power Holding Company of Nigeria centralized at the National Control Centre in Osogbo, Osun State, Nigeria. The control centre was visited and the operation control engineers interviewed on the operation mode of the system. The information obtained was analyzed based on the available theoretical guides and the level of success recorded so far by the method. The result of the analysis reveals that a virile and more reliable system for load management need be discovered for effective system operation and increased overall power availability. A Load management automation system was designed which has the ability to compare the power allocated and the instantaneous power being consumed by the regional stations and then instruct any station that is consuming excess to cut down the amount of power corresponding to the difference within the limit of stability factor of the system at which the system automatically effect the command if no action is taken by the station. The system is believed to have what is required to prevent under-frequency system collapse.

Keywords: power instability, automation, analysis, design, regional station.

INTRODUCTION

Electrical power system consists of generation transmission and distribution of electricity (Gupta, 2005). In order to keep the power system healthy, planning, control and data acquisition and analysis are of paramount importance. In other words, electrical system operation comprises operation planning, operation control and operation data acquisition and analysis (Deshpande, 2006). These three components of system operation when handled carefully can go a long way in ensuring and maintaining system synchronism (Weedy and Cory, 1998).

Transmission of electricity is therefore the transfer or conveyance of generated power to various and wide areas through a transmission network carefully designed to withstand a system voltage within the range of 330kv and 132kv. In view of the voltage level expected to be handled by this network, the network is usually expected to be electrically and mechanically sound. In effect, the success of the distribution network depends on the level of reliability and availability of both generation and transmission networks (Folarin, 2007).

In essence, any fault in either generation or transmission affects the distribution network (Oke et al, 2006). For instance, the August 2003 transmission system fault in the USA led to a cascading failure which saw the rapid loss of 61,000MW of load and affected an estimated 50 million consumers, (Oke et al, 2006).

The effect of system operation control is usually felt all through the system and therefore affects the level of success recorded in electric power system. This paper sets out to examine the system operation control of the National Control Centre of the Power Holding Company of Nigeria.

Objective of the study

- To find out the problems of power system in Nigeria.
- To suggest the ways by which power system in Nigeria can be improve
- To design an operating technique that will improve on load management on the grid

Definition of terms

Operation planning: this involves planning for optimum utilization of the installed generating capacity of the power station in response to the load demand on the grid system.

Power system automation: this is the application of automation devices to the electric transmission or distribution.

Operation control: this has to do with maintaining the entire power system in a continuous steady state operation.

Power system stability: this is referred to as the capability to return to the original equilibrium position on the occurrence of a disturbance or to another equilibrium state which is generally in the proximity of the initial equilibrium points.

Load demand: this is the actual amount of load on a circuit at any time. The sum of the entire loads which are ON is equal to the connected load minus the loads that are OFF.

Spinning reserve: this is the reserve generating capacity running at a zero load and synchronized to the electric system.

System collapse: this is the condition in which the steady state of power system is altered and lead to total breakdown of the system.

ELECTRIC POWER SYSTEM OPERATION CONTROL

This is practical realization of achievement made in operation. It includes up-to-date maintenance of major indices of the conditions of power system stations such as water level of hydro power stations, quantity of fuel available to thermal station, load demand by the consumers, conditions of each of the turbine generator unit in each of the power stations, spinning reserves, situation of the transmission lines, circuit breaker, reactor and power transformers (Deshpande, 2006).

All these are made use of during operation control from National Control Centre, situated at Osogbo in Osun State, Nigeria. From NCC, the control signals are sent to all necessary stations to effect necessary operations i.e. opening or closing of a particular breaker in transmission substation or generating station, loading of the spinning reserves and starting of generators.

LOAD MANAGEMENT

It is a basic requirement that a balance be ensured between the power generated and the load demand. If the consumer is drawing more power than the amount generated, the frequency of the system tends to decrease whereas the frequency goes up when consumers are drawing less than the generated power (Oke at al, 2006).

The National Control Centre of the PHCN is responsible for maintaining a pal between the power generated and the instantaneous load being consumed by the regional stations. This is achieved by monitoring the system frequency and then passes the necessary information across to the various stations on the grid depending on the condition of the system frequency.

RESEARCH METHODOLOGY

Data Collection

This research work was accomplished by collecting raw data from the National Control Centre of the Power Holding Company of Nigeria located at Osogbo in Osun State. This was considered fit because the National Control Centre (NCC) is the data bank of PHCN and equally responsible for the task of operation control of the various generation and other transmission and sub-transmission stations. Oral questions were asked from the system operation control engineers.

Specifically, data are collected on the following; Monthly Maximum Demand / Generation Analysis in MW (January – December 2006), PHCN System Generation Peak Load (Forecast and Actual) January – December 2006, Summary of Occurrence Maximum Peak Load Demand in year 1992-2006.

All the available raw data are shown in Table 1.0 – 3.0 below.

TABLE 1.0: MONTHLY MAXIMUM DEMAND/ GENERATION ANALYSIS IN MW (JANUARY –DECEMBER 2006)

MON	KAINJI	JEBBA	SHIRORO	AES	EGBIN	SAPELE	AFAM	DELTA	OKPAI	AJAOKUTA	IJORA	CALABAR	OMUKU	PEAK	DATE OF PEAK	TIME OF PEAK
JAN	405	388	398	197.7	1073	0	260	425	439	46		0		3631.7	06-Jan-06	07:45PM
FEB	312	484	539	217.3	1003	0	168	419	224	38				3404.3	04-Feb-06	05:00 PM
MAR	230	320	436	230	684	0	218	459	446	43				3066	08-Mar-06	09:45 PM
APR	378	332	420	255.9	542	0	249	498	430	38				3142.9	07-Apr-06	07:30 PM
MAY	314	332	418	255.1	774	0	235	320	441					3059.1	09-May-06	08:00 PM
JUN	204	252	392	191.4	660	0	272	388	457	50				2866.4	21-Jun-06	09:45 PM
JUL.	181	341	375	266.5	644	0	247	557	383	41				3035.5	20-Jul-06	09:00 PM
AUG	186	180	416	232.9	673	74	291	479	394	76				3001.9	31-Aug-06	07:00 PM
SEP.	319	460	568	209.8	487	74	259	467	465	76				3384.8	17-Sep-06	07:00 PM
OCT.	366	508	600	260.3	561	64	296	484	465	78				3682.3	27-Oct-06	06:00 PM
NOV	290	480	564	234.3	586	65	281	464	458	65				3487.3	03-Nov-06	08:30 PM
DEC.	408	435	430	251.2	659	64	190	447	439	90		0	29.8	3443	21-Dec-06	08:00 PM

Source: Generation and Transmission Grid Operations - National Control Centre, Osogbo

TABLE 2.0: SYSTEM GENERATION PEAK LOAD (FORECAST AND ACTUAL) JANUARY- DECEMBER 2006

MONTH	WEEK 1		WEEK 2		WEEK 3		WEEK 4		WEEK 5		MONTHLY PEAK LOAD	
	FORECAST	ACTUAL	FORECAST	ACTUAL	FORECAST	ACTUAL	FORECAST	ACTUAL	FORECAST	ACTUAL	FORECAST	ACTUAL
JAN.	8000	3631.7	8000	3593.4	8000	3573	8000	3606	8000	3399	8000	3631.7
FEB.	8100	3404.3	8100	3377.8	8100	3245	8100	3081	8100	3043	8100	3404.3
MAR.	8100	3027	8100	3066	8100	2980	8100	3030	8100	3035	8100	3066.0
APR.	8300	3142.9	8300	3022.8	8300	3116	8300	3046	8300	2906	8300	3142.9
MAY.	8000	2966.3	8000	3059.1	8000	2941	8000	2880	8000	2816	8000	3059.1
JUN.	7800	2656.8	7800	2828.3	7800	2778	7800	2866	7800	2474	7800	2866.4
JUL.	7700	2876.7	7700	2928.3	7700	3036	7700	3026	7700	2712	7700	3035.5
AUG.	7600	2897.7	7600	2893.3	7600	2854	7600	2852	7600	3002	7600	3001.9
SEP.	8500	2968.9	8500	3137.6	8500	3339	8500	3385	8500	3384	8500	3384.8
OCT.	8650	3444.2	8650	3532	8650	3634	8650	3682	8650	3482	8650	3682.3
NOV.	8800	3487.3	8800	3429.1	8800	3269	8800	3276	8800	3357	8800	3487.3
DEC.	8950	3175.7	8950	3227.2	8950	3422	8950	3443	8950	3397	8950	3443.0

Source: Generation and Transmission Grid Operations - National Control Centre, Osogbo

TABLE 3.0: SUMMARY OF OCCURRENCE MAXIMUM PEAK LOAD DEMAND IN YEAR 1992-2006

YEAR	PEAK LOAD (WM)	MONTH	TIME OF OCCURRENCE
1992	2382.00	10-Dec-92	8:30PM
1993	2330.00	10-Nov-93	07:00PM
1994	2446.00	07-Feb-94	08:00PM
1995	2452.00	13-Nov-95	07:30PM
1996	2470.00	06-Dec-96	07:30PM
1997	2457.00	29-Jan-97	07:45PM
1998	2412.00	07-Sep-98	09:30PM
1999	2458.00	19-Nov-99	07:30PM
2000	2499.00	31-Dec-00	08:15PM
2001	2934.49	31-Dec-01	08:30PM
2002	3223.30	05-Dec-02	08:45PM
2003	3479.30	29-Aug-03	07:45PM
2004	3427.5	30-Sep-04	08:00PM
2005	3774.4	08-Aug-05	20:15PM
2006	3682.3	27-Oct-06	06:00AM

Source: Generation and Transmission Grid Operations - National Control Centre, Osogbo

Findings

The following information were gotten on system operation control of the National Control Centre of the Power Holding Company of Nigeria through oral questions asked from the technical personnel of the establishment:

- That load allocation to each of the regional control centre is not based on any automated system but rather on preference and availability of the transmission line linking the stations;
- That under-load and over-load frequency tripping is achieved with the aid of automated system designed to ensure that the system frequency is maintained within the specified limit or tolerance;
- That the power system control that adopts the use of governor control system is not effective on the system. This has made it very difficult to ensure system operation control to its maximum advantage.
- That fault location and tracing on the system network is relatively tedious in view of absence of automated control system that is capable of diagnosing the entire system or part of it within some micro-second;
- That reliability index of the 330KV feeders on the grid system is average at about 0.93;
- That the method of communication between the National Control Centre and the regional stations is based on the use of Power Line Carrier, Radio Communication System and the Global System for Mobile Communication (GSM).
- That the time-lag between when the information is passed and the action taken by the recipient in regional stations is a major cause of under frequency system collapse. It was gathered that it takes time atimes before communication link is established between the control centre and the end target.

Data Analysis

It is clear, from the findings that the entire grid lacks the required control system that is capable of managing the power generated and load demand at any time. The grid system operates with inadequate automated control system. This is identified as one of the major problems against effective utilization of spinning reserve. Hence, the system operation control for load and generation management relies so much on the use of communication lines.

To this effect, effective system operation control depends on the level of reliability of the communication system and the amount of cooperation exhibited by the operation personnel in various generating stations and regional control stations. The time lag between manual observation of the system frequency and the giving of necessary information is enough for the system to collapse. This is often the reason for system instability even when fault could be prevented to a large extent.

SYSTEM DESIGN FOR LOAD MANAGEMENT AUTOMATION

Load management automation is a concept born out of the need to ensure that sum of load consumed by regional stations and line losses are relatively equal to the total generation when it becomes difficult to make use of the spinning reserve on the grid system in view of lack of effective turbine-generator control system.

Analysis of the system operation control of the National Control Centre in Nigeria shows that load and generation management is a major problem confronting the national grid. It is relatively difficult to control the amount of power being taken by each regional station. Considering the outcome of the analysis that reveals that system collapse on low frequency is usually due to breakdown in communication link and slow response of the control personnel in other regional stations, it is therefore necessary to develop load auto-controller to be able to monitor the load.

System Design Requirements

This power system management is expected to do the following:

- It must be able to eliminate dependence on the use of power line carrier, radio communication and GSM for dissemination of control instructions
- It must be able to overrule dependence of effective control on the personnel
- It must be able to monitor the grid system, generate control instruction and execute it within some permitted micro-seconds in order to avert system collapse
- It must be simple to understand and flexible to modify

Principle of Operation

This system tends to ensure that the available generation is shared adequately among the regional stations. This is achieved by calculating the percentage average load demand for each regional station if the average load demand by the regional stations is known. With this, the system calculates power allocation to each of the stations.

The system at any time, t compares the power allocated to each station and the instantaneous load by the station and thereafter instructs any station that is taking more power than allocated to it to shut down the amount of power corresponding to the difference. With this provision, the system can diagnose itself and then follow the path of the command that follows. The use of power line carrier, GSM, or radio communication which may cause delay in getting through is avoided.

The program flowchart and soft code is as shown in the Appendix I & II.

System Design

Database is created for the regional stations and the base station.

The information on each regional station includes: Name, Town, State, Code, Average load demand, percentage average load demand, load allocated, and the base station has power generation and average total load demand in addition. The base station (control centre) is also able to view any of the stations data. Average load demand by the stations can be gotten from load consumption data over time.

$$\text{Total Average Load Demand} = \sum_{x=1}^{n} D_x$$

Where D, is the Average Load Demand by each station.

$$\text{Percentage Average Load Demand} = \frac{\text{Average Load Demand}}{\text{Total Average Load Demand}}$$

Load Allocated = Percentage Average Load Demand X Total Generation

Having all these values, Visual Basic Programming was used to establish communication and system control between the various regional stations and the base station. Visual Basic is considered appropriate in view of its interactive and flexible nature.

Limitation to the System

This system lacks the provision for over-frequency control. If a station is taking less than the power allocated to it, the system cannot effect control. However, the over-frequency system control is expected to be able to cater for this. More so, instance of system collapse on under-load (over-frequency) was not reported at the National Control Centre.

System Testing

The system was tested by supplying the required data into the system. However, since the hardware requirement was not available, the instantaneous power consumed was altered manually on the system. The system was found okay and efficient.

CONCLUSION AND RECOMMENDATION

Conclusion

Having done all necessary things within the scope of these study, it can be concluded that the problems of power system in nigeria is multi-dimensional covering the three stages involve in power system; the generation, the transmission and the distribution. However, deficiencies in system operation is a major contributor to the said problem in that effective system operation determine top large extent to which the system will be available.

The lack of control system that is computer based such that fault can be effectively managed, prevented or resolved within minimum time available that will help in ensure high system availability factor. The joke made so far in system operation control by not giving it serious attention it requires is too costly and it has done so much evil to the system.

Power generation system in Nigerian is of higher capacity than the load demand. More explicitly, the installed capacity in Nigeria is greater than the national load demand whereas the available capacity is very much below expectation. Hence, power generating station in Nigeria are facing great problem of drastic fall in availability factor. This is usually a result of poor maintenance culture of the power station, lack of proper planning, shortage of spare parts, lack of skilled labour, e.t.c.

In all, system operation control will be highly improved if the use of power system automation is adopted. This will go a long way in ensuring effective management of load and generation especially where the use of spinning reserve is impossible.

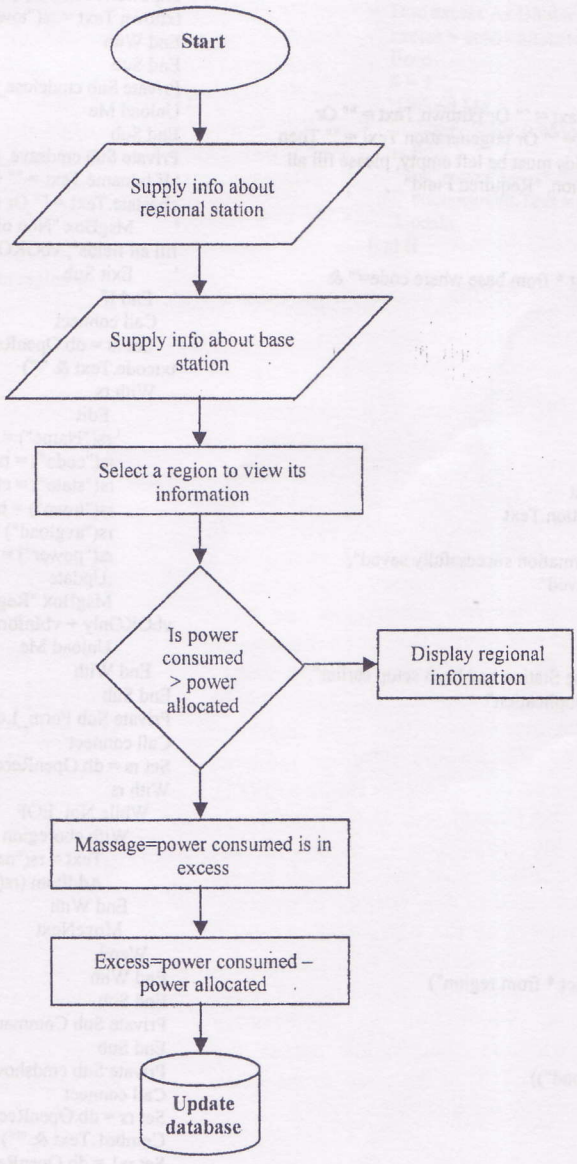
Recommendation

Based on the study carried out, the following recommendations are made:

- That the generator control strategies in all power generating stations be improved. This improved controller must be able to track parameter changes (effect parameter identification) and to adapt controller actions to the "changing condition of operation and load". They should also be able to minimize the impact of random disturbances on system state variation.
- That there should be improved penstock-turbine models which would have to be employed for controller design.
- Research and development directions need be articulated to support current low levels of indigenous research and technological activities.
- Improved training of personnel should be encouraged and taken with all seriousness as this will go a long way in enhancing personnel performance
- Hydraulic coupling effect should minimized by spreading out the sitting of hyro power plants to other viable location around the country.

- The culture of planned maintenance, by qualified personnel, need be strengthened in addition to adequate provision of spare part that will aid timely maintenance of power plants, transmission lines and equipment.
- Routine patrol and inspection of over head lines will prevent the avoidable fault caused by three encroachments. In essence, proper attention should be given to regular need for prompt need for prompt clearance of route taken by power line through improved funding, supervision and management by the government.
- In order to establish a link between the control centre and the regional stations, Fiber Optic Technology is recommended to be used as the backbone having the advantage of reduction in initial cost because it is already lashed on the grounding wire of both 330KV and 132KV lines.
- A gradual replacement of all cross arms and/or insulator should be undertaken.
- System replacement of wooden poles with reinforced concrete poles will reduce fault occurrence on the distribution lines. If wooden poles should be used they should be subjected to standard test characteristics of height, tensile strength, and heat treatment.
- Fault tracing/ clearance mechanism should be update while the fault men should be retained regularly.
- Bulk allocation of service material should be made to districts and undertakings for prompt clearance of fault.
- Effort should be put in place to ensuring fair billing, reducing time delay in energy meter processing, adequate record keeping of consumers in order to combat illegal connection.

PROGRAM FLOWCHART



REFERENCE

Deshpande M. V. (2006): Electrical Power System Design. Tata McGraw-Hill Publishing Company Limited. New Delhi. Pg 150-160

Folarin D.A. (2007): Due Process and Rule of Law in Power Distribution Management for Sustainable Development in Developing Nation. Book of Proceeding, International Conference of School of Applied Sciences, Engineering and Environmental Technology, Federal Polytechnic, Ede. Pg 197-202.

Gupta B. R. (2005): Power System Analysis and Design. S.Chand and Company LTD. Ram Nagar, New Delhi. Nigeria Energy Digest Vol 1,No 5,July 31st 2000

Oke A. O., Aderoba A. A. and Oyebisi T. O. (2006): Aggregate Model for Predicting Electricity Demand in Nigeria. Nigerian Journal of Industrial and System Studies. Vol. 5, No 3. Pg 25-30

Weedy B. M. and Cory B. J. (1998): Electric Power Systems. John Wiley & Sons. Chichester. Pg 167-181, 319-339.

SOFT CODE

```
Sub clear()
txtname.Text = ""
txtcode.Text = ""
txtstate.Text = ""
txtload.Text = ""
txtgeneration.Text = ""
txttown.Text = ""
End Sub
Private Sub cmdclose_Click()
Unload Me
End Sub
Private Sub cmdsave_Click()
If txtname.Text = "" Or txtcode.Text = "" Or txttown.Text = "" Or
txtstate.Text = "" Or txtload.Text = "" Or txtgeneration.Text = "" Then
MsgBox "Non of the required fields must be left empty, please fill all
fields", vbOKOnly + vbExclamation, "Required Field"
Exit Sub .
End If
Call connect
Set rs = db.OpenRecordset("select * from base where code='" &
txtcode.Text & "'")
With rs
  If .RecordCount < 1 Then
    .AddNew
    rs("Name") = txtname.Text
    rs("code") = txtcode.Text
    rs("state") = txtstate.Text
    rs("town") = txttown.Text
    rs("totalload") = txtload.Text
    rs("generation") = txtgeneration.Text
    .Update
    MsgBox "Base Station Information successfully saved",
vbOKOnly + vbInformation, "Saved"
  Me.clear
  txtname.SetFocus
  Else
    MsgBox "The specified Base Station had been setup earlier",
vbOKOnly + vbExclamation, "Duplication"
    Me.clear
    txtname.SetFocus
  End If
End With.
End Sub
Private Sub cmdview_Click()
frmgetregion.Show (vbModal)
End Sub
Private Sub Form_Load()
txtload.Locked = True
Call connect
Set rs = db.OpenRecordset("select * from region")
With rs
  Dim total As Double
  While Not .EOF
    total = total + Val(rs("avgload"))
    .MoveNext
  Wend
  txtload.Text = total
End With
End Sub
Private Sub cboregion_Click()
Call connect
Set rs = db.OpenRecordset("select * from region where name='" &
cboregion.Text & "'")
With rs
'   rs("Name") = txtname.Text
txtcode.Text = rs("code")
cbostate.Text = rs("state")
txtload.Text = rs("avgload")
txtpower.Text = rs("power")
txttown.Text = rs("town")
End With
End Sub
Private Sub cmdclose_Click()
Unload Me
End Sub
Private Sub cmdsave_Click()
' If txtname.Text = "" Or txtcode.Text = "" Or txttown.Text = "" Or
cbostate.Text = "" Or txtload.Text = "" Or txtpower.Text = "" Then
'     MsgBox "Non of the required fields must be left empty, please
fill all fields", vbOKOnly + vbExclamation, "Required Field"
'     Exit Sub
'  End If
  Call connect
  'Set rs = db.OpenRecordset("select * from region where code='" &
txtcode.Text & "'")
  With rs
      .Edit
    ' rs("Name") = txtname.Text
      rs("code") = txtcode.Text
      rs("state") = cbostate.Text
      rs("town") = txttown.Text
      rs("avgload") = txtload.Text
      rs("power") = txtpower.Text
      .Update
      MsgBox "Region Information Updated successfully",
vbOKOnly + vbInformation, "Updated"
      Unload Me
  End With
End Sub
Private Sub Form_Load()
Call connect
Set rs = db.OpenRecordset("select * from region")
With rs
  While Not .EOF
    With cboregion
      .Text = rs("name")
      .AddItem (rs("name"))
    End With
    .MoveNext
  Wend
End With
End Sub
Private Sub Command1_Click()
End Sub
Private Sub cmdshow_Click()
Call connect
Set rs = db.OpenRecordset("select * from region where name='" &
Combo1.Text & "'")
Set rs1 = db.OpenRecordset("select * from base ")
With rs
  txtcode.Text = rs("code")
```

```
txtconsumed.Text = rs("power")
Dim a As Double
Dim b As Double
Dim c As Double
Dim demand As Double
a = rs("avgload")
b = rs1("totalload")
c = rs1("generation")
demand = a / b
txtdemand.Text = demand
txtallocated.Text = c * demand
If Val(txtconsumed.Text) > Val(txtallocated.Text) Then
   Dim excess As Double
   excess = Val(txtconsumed.Text) - Val(txtallocated.Text)
   Beep
   S = 5
   ' Unload Me
   frmnotify.Show (vbModal)
   rs.Edit
      rs("power") = c * demand
      txtconsumed.Text = rs("power")
   .Update
  End If
  End With
'If Val(txtconsumed.Text) > Val(txtallocated.Text) Then
'   Dim excess As Double
'   excess = Val(txtconsumed.Text) - Val(txtallocated.Text)
'   Beep
'   S = 20
'   ' Unload Me
'   frmnotify.show (vbModal)
'End If
End Sub

Private Sub Command2_Click()
Unload Me
End Sub
Private Sub Form_Load()
txtconsumed.Locked = True
Call connect
Set rs = db.OpenRecordset("select * from region")
With rs
  While Not .EOF
    With Combo1
      .Text = rs("name")
      .AddItem (rs("name"))
    End With
    .MoveNext
  Wend
End With
End Sub
```

```
Private Sub tmrexcess_Timer()
lblexcess.Visible = Not lblexcess.Visible
End Sub
Private Sub timer1_Timer()
End Sub
Private Sub Command1_Click()
Form3.Show
End Sub
Private Sub Form_Load()
Call connect
Set rs = db.OpenRecordset("select * from region")
Set rs1 = db.OpenRecordset("select * from base ")
With rs
Dim cons As Double
Dim allocated As Double
Dim dem As Double
  cons = rs("power")
  Dim a As Double
  Dim b As Double
  Dim c As Double
  Dim demand As Double
  a = rs("avgload")
  b = rs1("totalload")
  c = rs1("generation")
  demand = a / b
  'dem = demand
  allocated = c * demand
  If cons > allocated Then
    Dim excess As Double
    excess = cons - allocated
    Beep
    S = 5
    ' Unload Me
'   frmnotify.Show (vbModal)
'   rs.Edit
'     rs("power") = c * demand
'     txtconsumed.Text = rs("power")
'   .Update
  End If
```