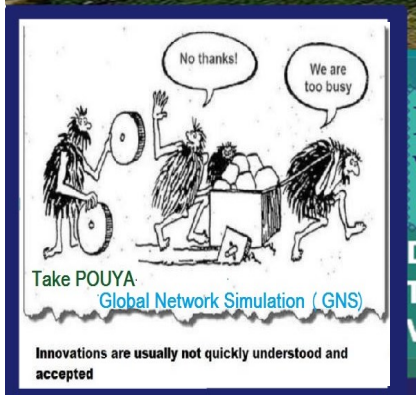
POWER SYSTEM SIMULATION



Professor Shahram Montaser Kouhsari

Visiting Professor of power system - electrical engineering at PolyU.
Coming from Amirkabir University of Technology (Tehran Polytechnic)

Date: 15 April 2016, Friday
Time: 6:30 - 8:30 pm
Venue: FJ 302, Department of Electrical Engineering, PolyU campus

Abstract

Power system operation already has many difficulties. The new energy resources coming in, have increased the power system operation and design problems. The only solution seems to be more accurate simulation.

In this talk we are going to speak about the merits of simulation. The advantages of real time simulation will be discussed by using a tool named POUYA software (www.intelectri.com).

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IEEE

IEEE(HK) PES/IAS/PELS/IES JC

THE HONG KONG POLYTECHNIC UNIVERSITY 香港理工大學 Department of Electrical Engineering

Special thanks to Ir Dr. Edward Lo,

SIMULATION

A computer simulation is a simulation, run on a single computer or a network of computers to reproduce behavior of a system.

In my talk I am going to introduce and use two programs named PASHA (stands for Power Apparatus and System Homological analysis) and POUYA (stands for Power-system Online-simulation Unveil Your Analysis).

I use these tools to explain why I think:

Power system operation already has many difficulties.

Why do we need more elaborate methodology?

What road should we go?

POWER SYSTEM SIMULATION

A brief summary of the tools (POUYA – PASHA software):

We usually have many questions about the behavior of a physical system and we use simulation to answer these questions. In power systems now a days we use digital simulation programs.

The task of simulation in power system usually needs:

Draw a SLD of a network that we are going to simulate.

Collect and input the network data.

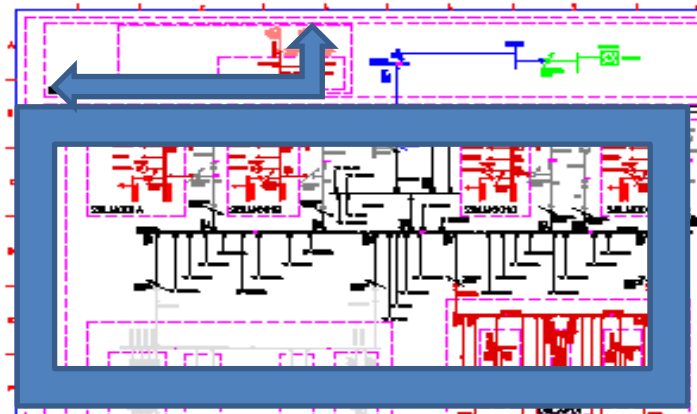
Divide the simulation tasks into predefined calculations.

Find answers of the questions.

http://www.tomcad.com/linkedin/POUYA.BAT

PASHA software like many other programs does these jobs:

Single Line Diagram(SLD) of a refinery represented in PASHA

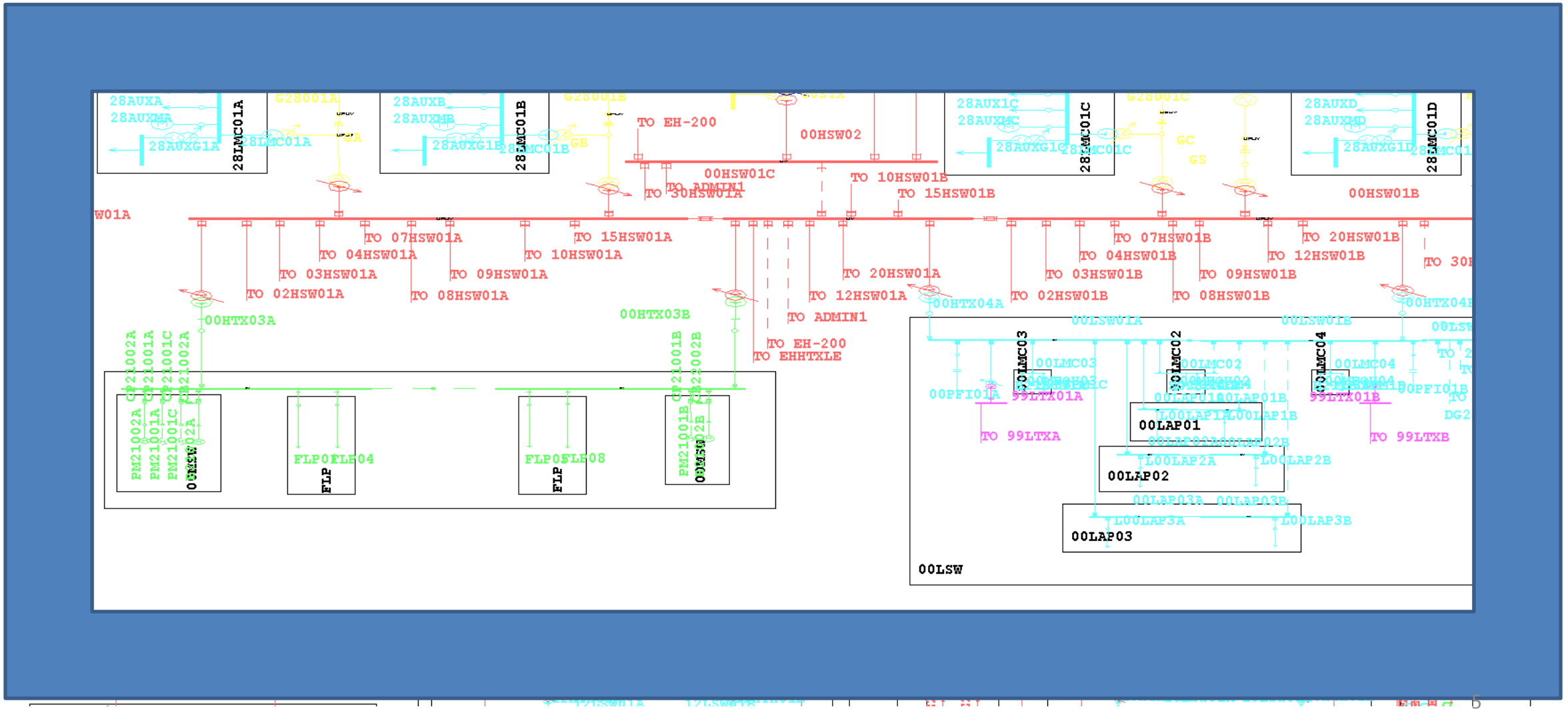


Simulation Modelling Practice and Theory
Volume 66, August 2016, Pages 50–62

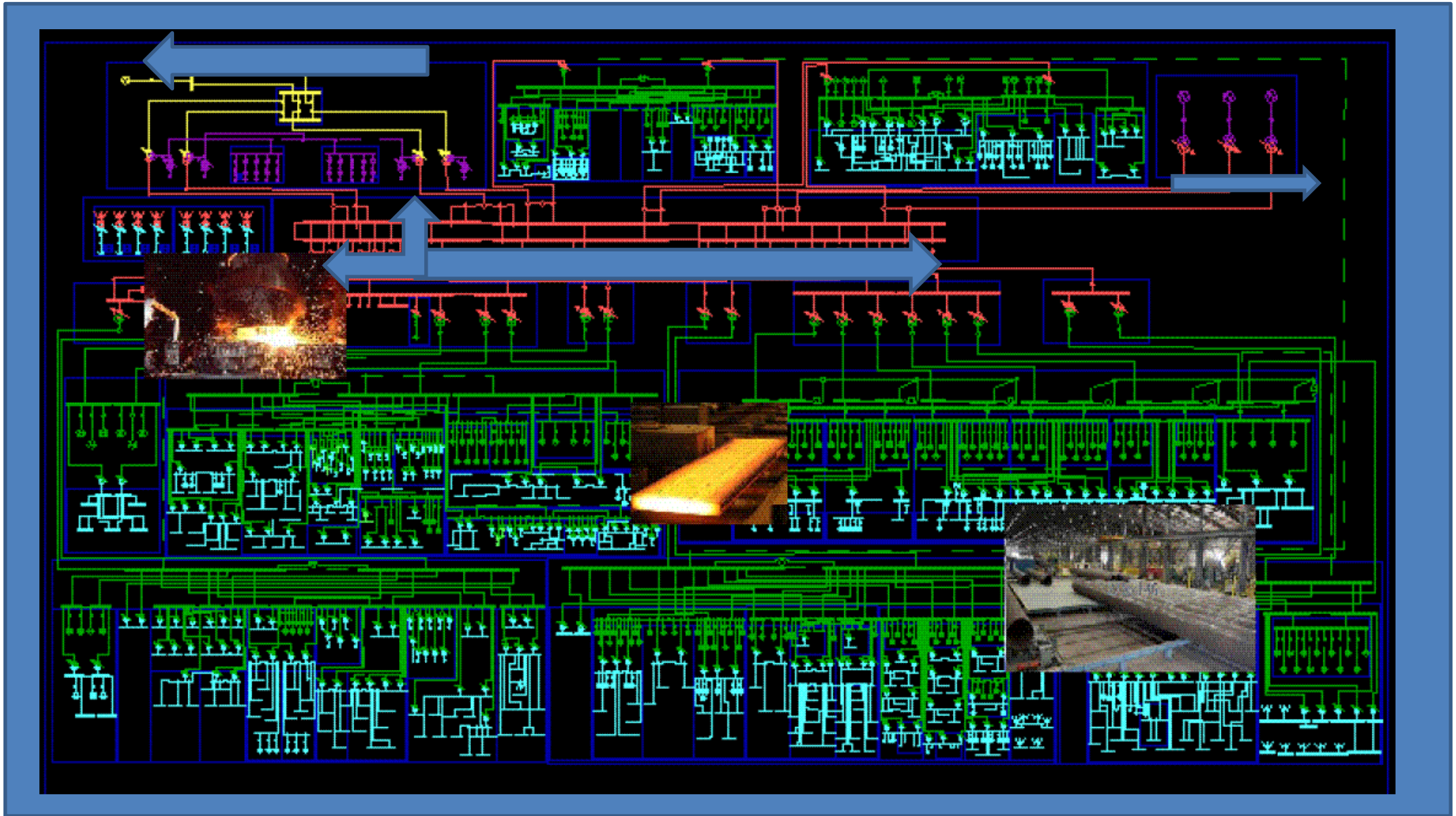
An efficient approach to handle the problem of load flow divergence in phasor based simulators

Amin Helmzadeh, Shahram Montaser Kouhsari

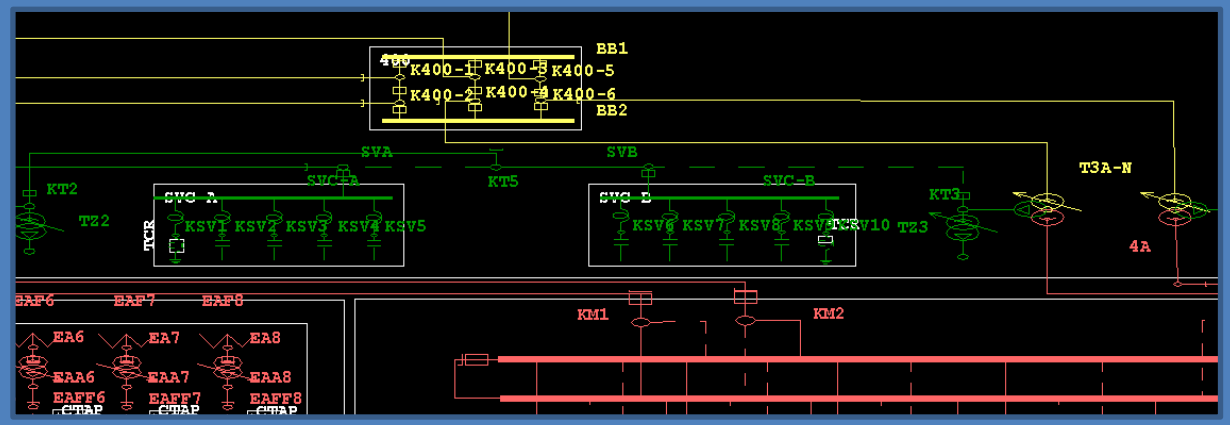
Main 20kV distribution substation in a refinery plant

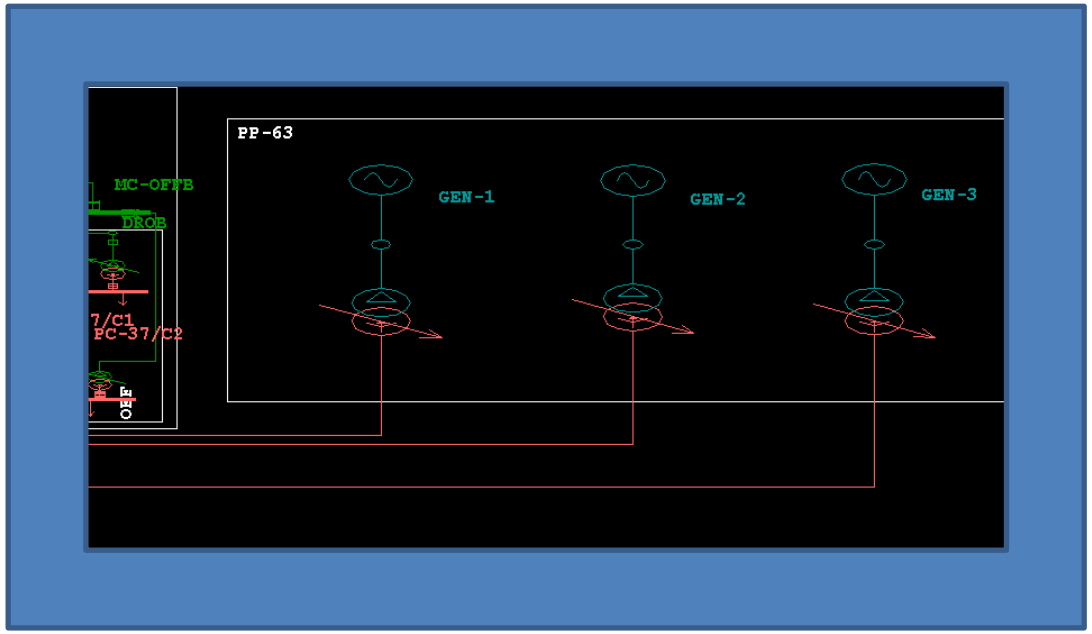


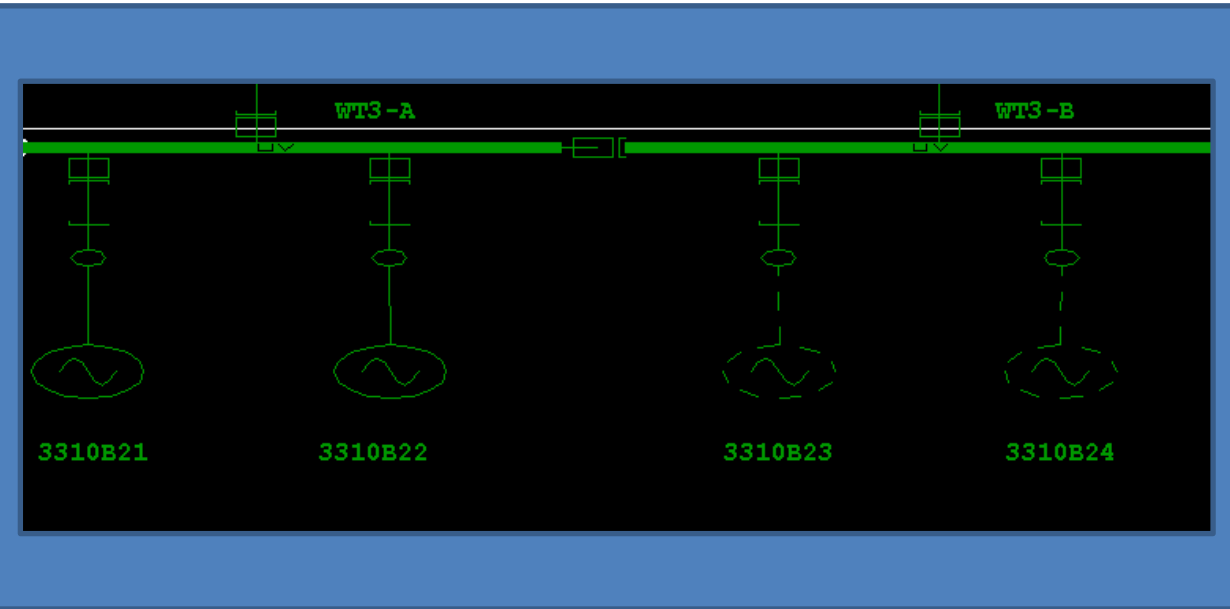
SLD of a Steel Mill Plant



Some parts of the steel mill plant SLD

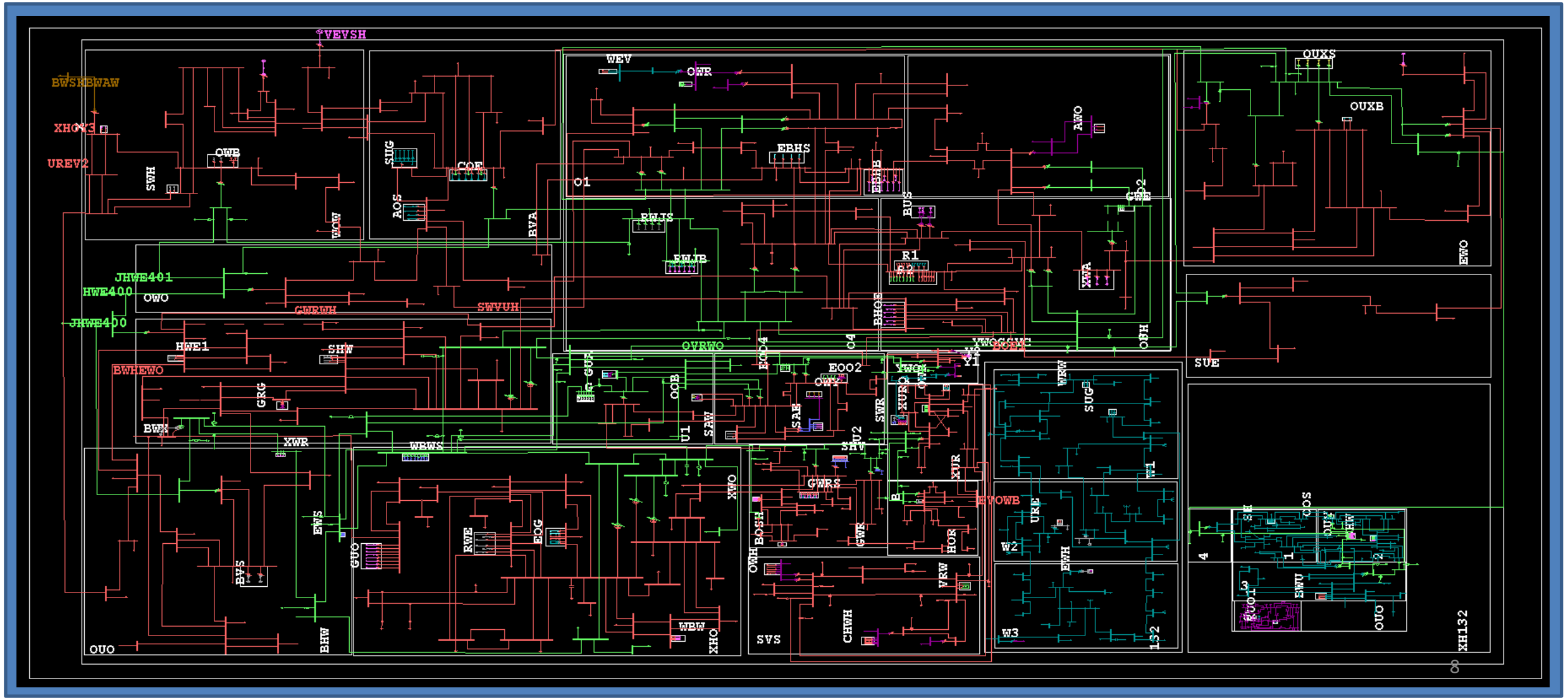






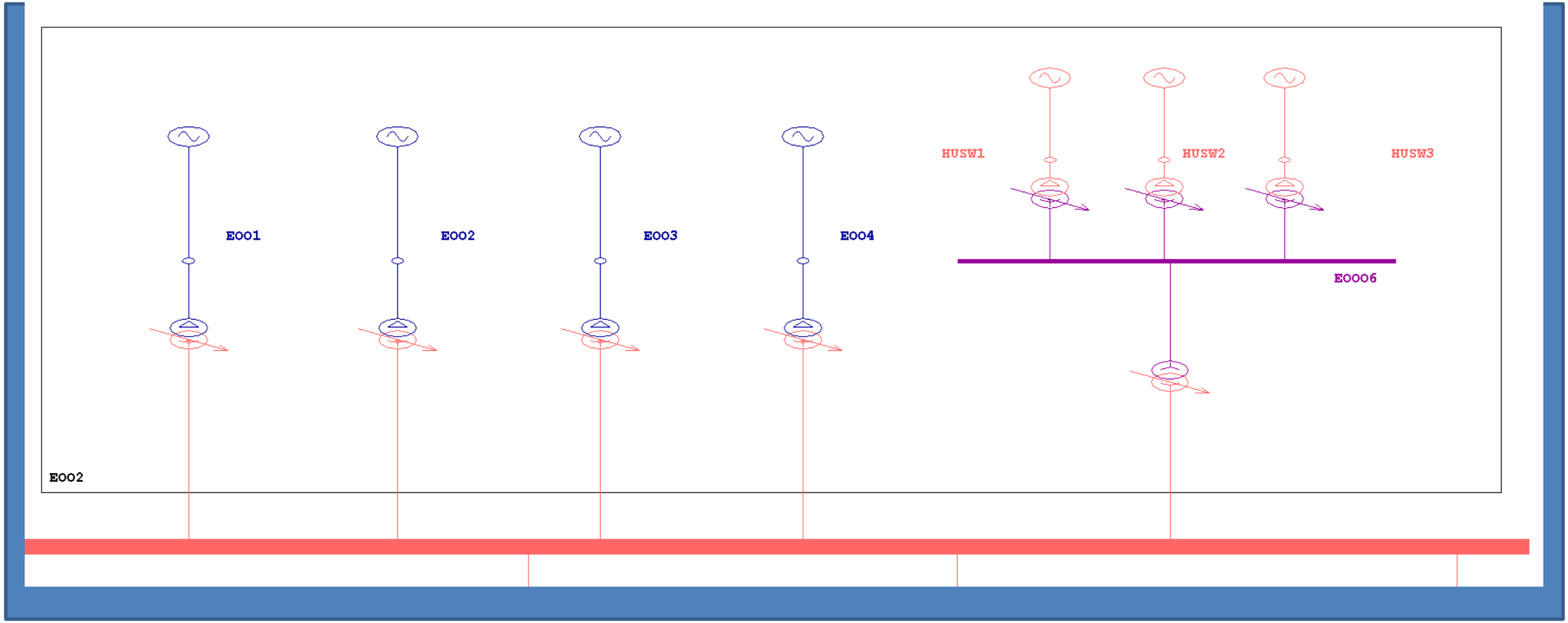
IRANIAN Interconnected Power System

An interconnected network 400kV-230kV-132kV-63kV(just a small portion), and generation stations



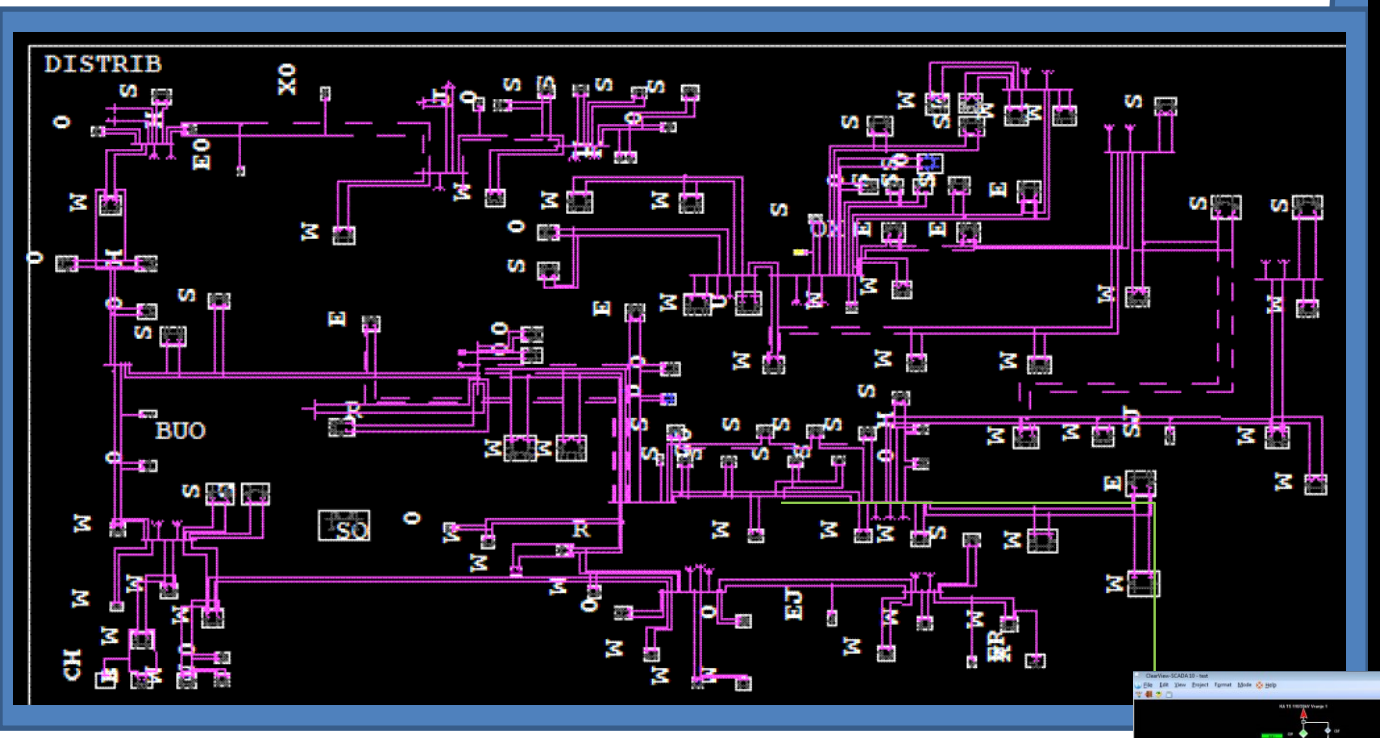
A generation station

An interconnected network 400kV-230kV-132kV-63kV(just a small portion), and generation stations

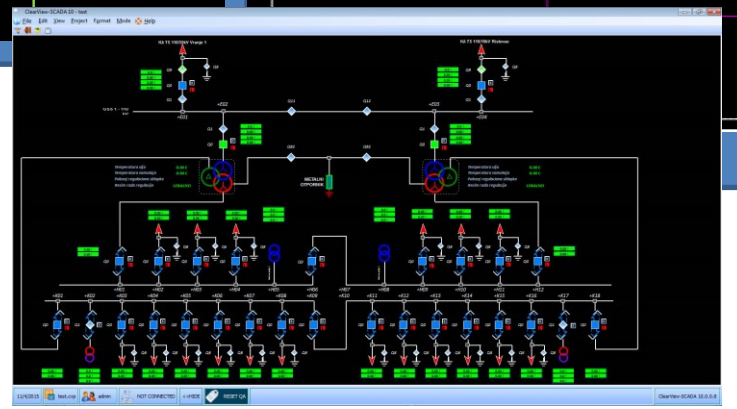


One of the generation station: 15.75kV-11kV-63kV-230kV

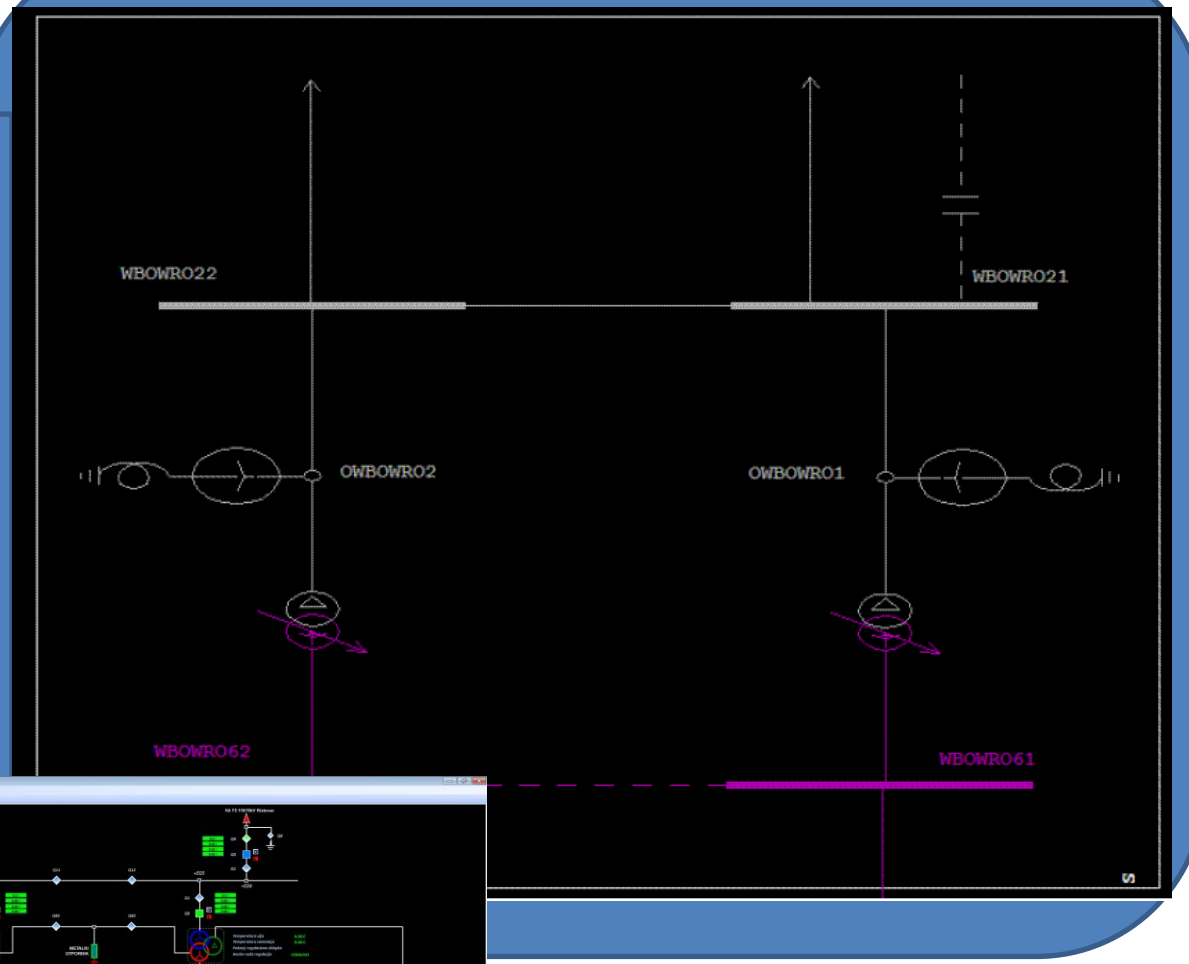
63 kV-20 kV network of a distribution system



63 kV/20 kV network of a distribution system Esfahan sub division from an interconnected grid.

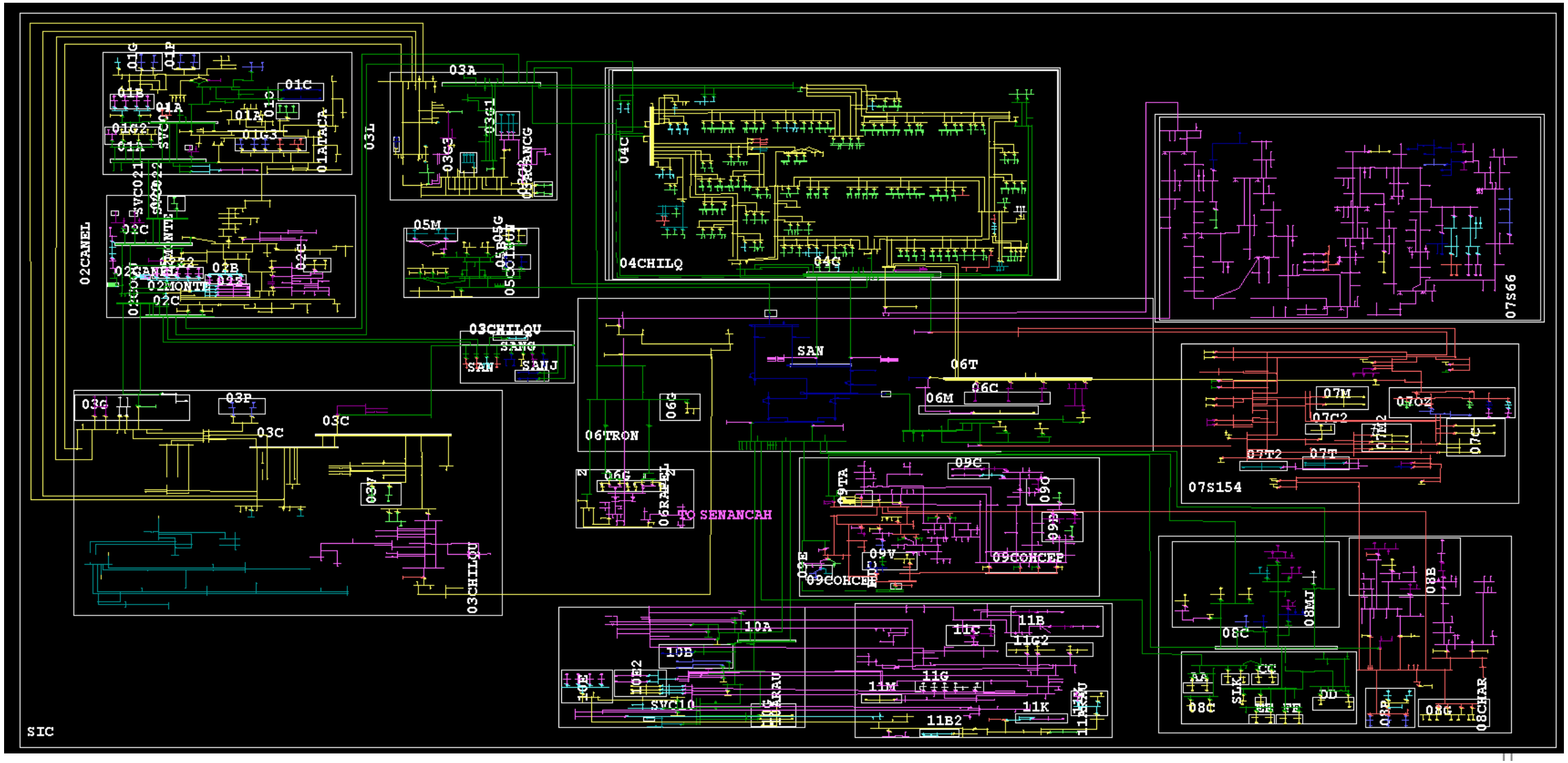


SCADA Monitoring



63 kV/20 kV substation.

The networks can also be brought from other software



PASHA is a program that handles most analysis of the power system including:

LOAD FLOW, Economic Dispatch, OPF, FAULT Analysis, TRANSIENT stability, Relay Coordination, CB checking, Relays set checking's, RELIABILTY evaluation, HARMONIC and filler design, many more…….

These tools solves many technical and economical problems.

But PASHA has (like its counterparts) its own problems:

1- Dealing with its routine is not easy, you need to read 700 pages manual to work with it

2- You need to have a lot of experiences on data entry. You need to be a simulation man.

3- Not all the calculations imitate the actual behavior of the system during the operation. For instant we do not have the actual load profile

4- If you know all of these still it is difficult to provide scenarios and deduct your conclusions.

Real Time Simulation

On the other hand the next software I will show you (that is POUYA) it is called to be a kind of real time simulator.

Real-time simulation refers to a computer model of a physical system that can execute at the same rate as actual "wall clock" time. In other words, the computer model runs at the same rate as the actual physical system. For example if a tank takes 10 minutes to fill in the real-world, the simulation would take 10 minutes as well.

However, any program that can handle a simulation faster than actual time, with a minor modification may become a real time simulator.

POUYA brings your archived networks and treat it as an actual power system.

Real Time Simulation

POUYA is indeed a power system dynamic simulator.

(uses transient stability routines and therefore it is phasor based)

POUYA can simulate the power systems in real time or even faster than real time.

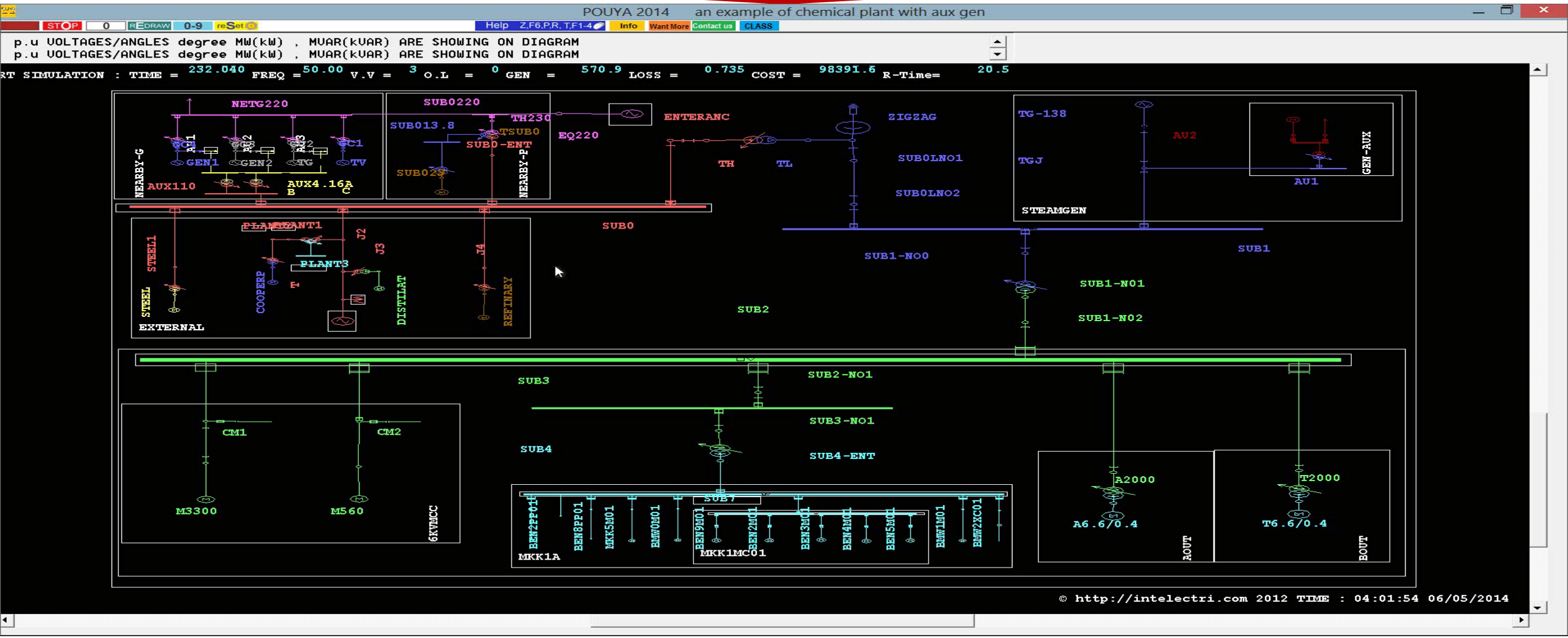

POUYA.lnk

http://www.tomcad.com/linkedin/POUYA.BAT

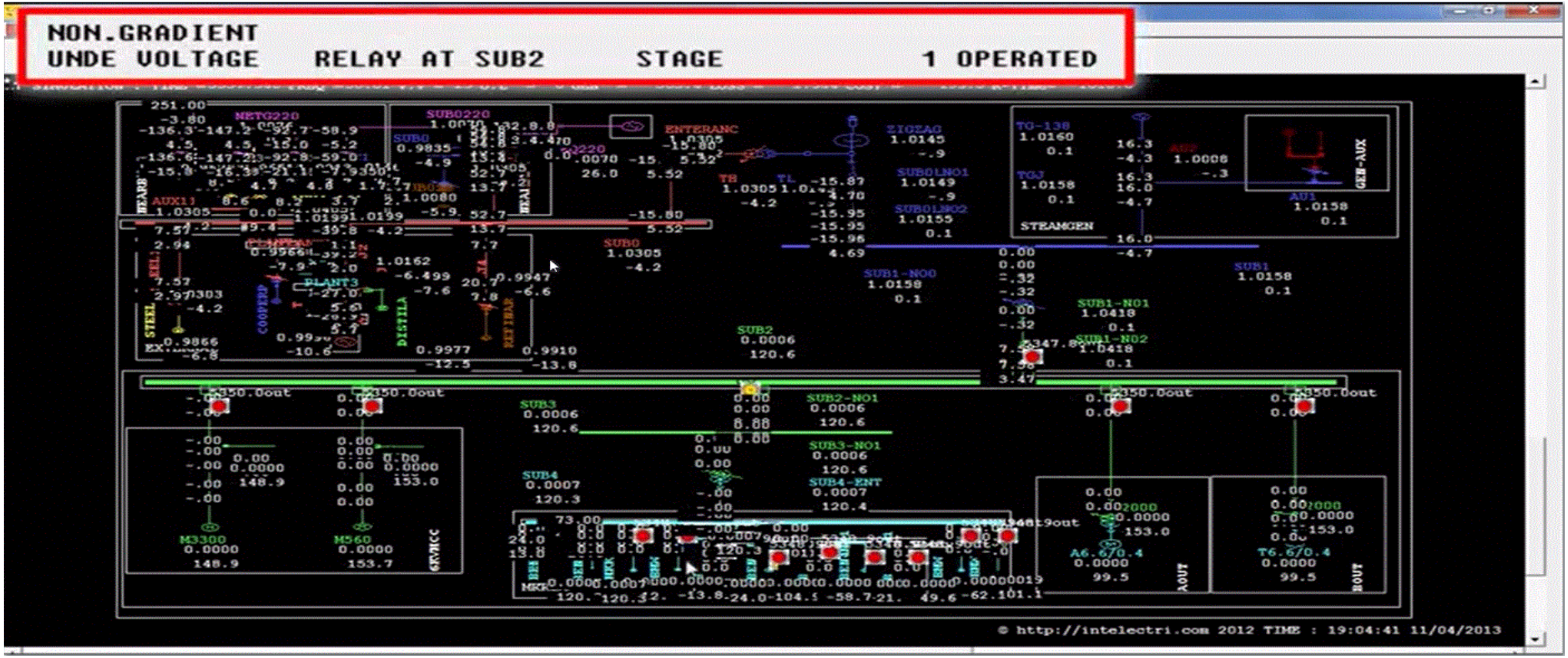
Before going to POUYA capabilities, we need to know how POUYA shows the results on diagram.

Power system
Online simulation
Unveil
Your
Analysis

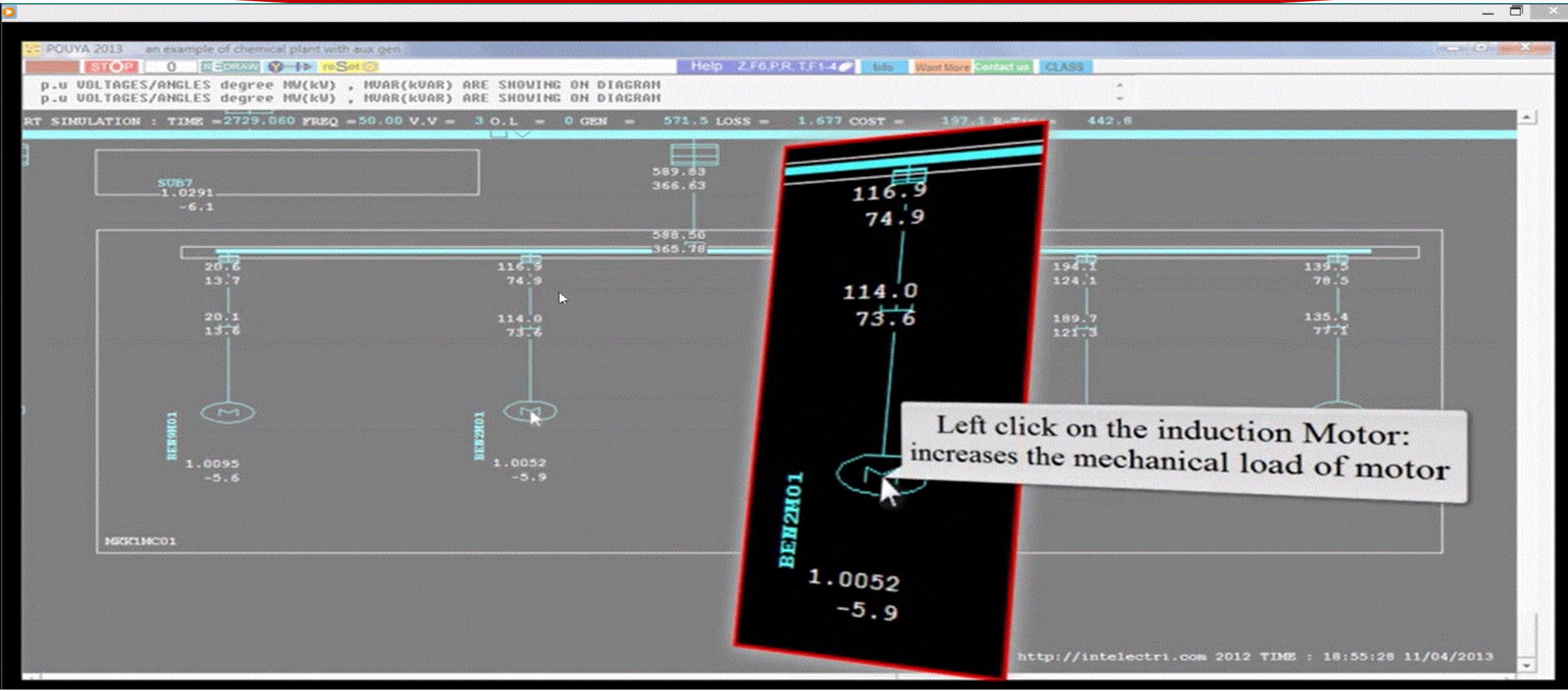
Real Time Simulation



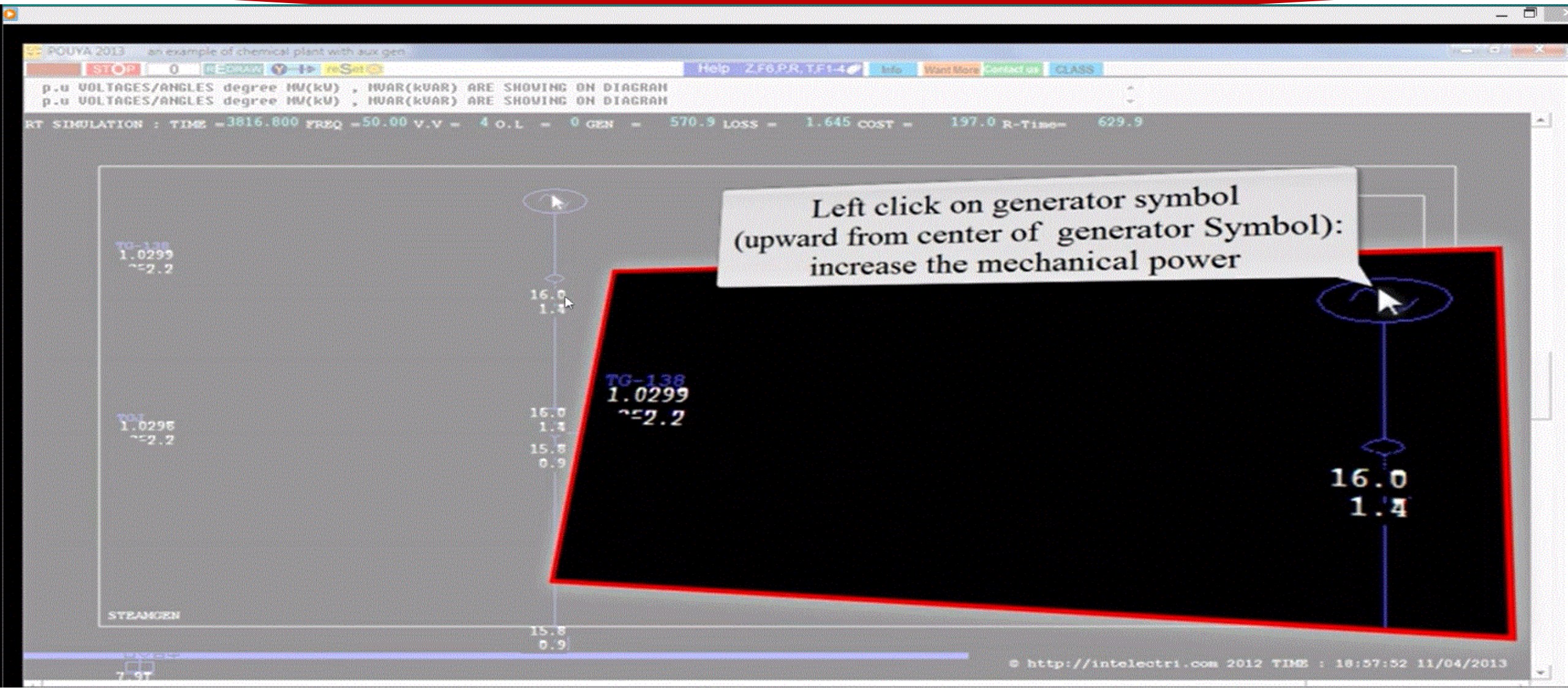
Real Time Simulation



Real Time Simulation



Real Time Simulation



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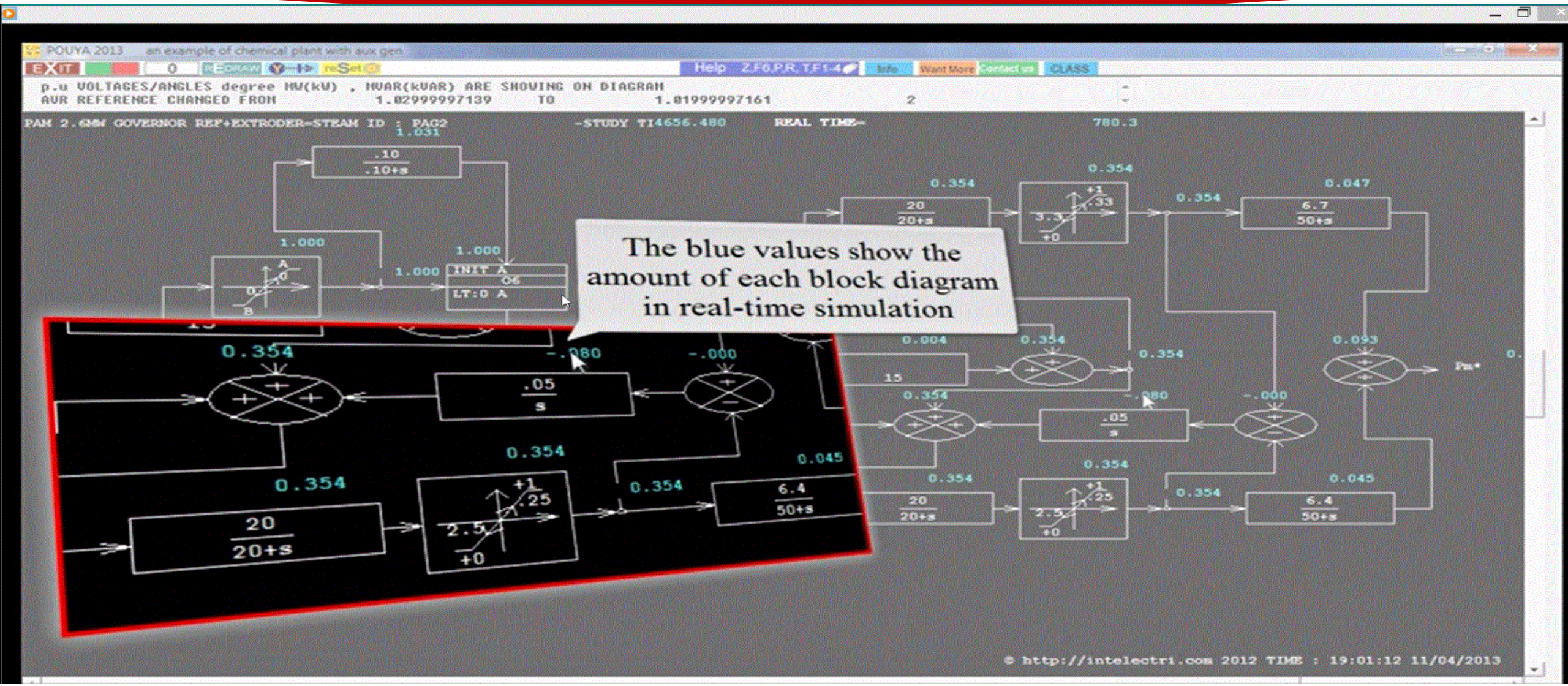


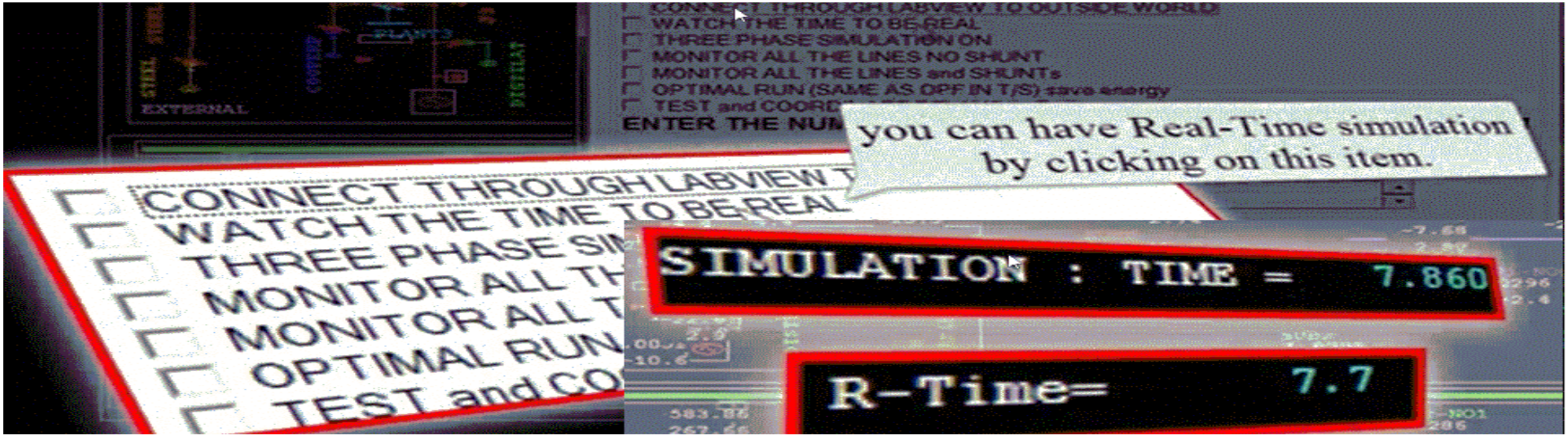
Real Time Simulation

Advantages of being Real Time:

1-Controlling the process through On _line connection

2-Get feeling on control actions

3- Synchronous the user actions in Global simulation



Real Time Simulation

POUYA is also a Web-based simulator.

This means that the networks can be shared on web:

It can also be used for education. Here is an automatic lab grading exercise:

Not all engineers needs to be a simulator expert, and therefore, they might need some support. POUYA provides on line remote support:

Webinar can be easily made. You can register and come to a prescheduled class:

POUYA.lnk

http://www.tomcad.com/linkedin/POUYA.BAT

Familiarity with Three Phase Fault calculations

Learning outcomes: Upon completion of the subject, students will:

1. Have famelirized with fault analysis using software
2. Have acquired in-depth understanding of power system three phase fault analysis
3. Have acquired ability to evaluate the Circuit Breaker rating in design(planning) stage and finding the effectivness of Circuit Breakers in operation stage
4. Have Known how to put an equivalent of power system network
5. Have acquired communication skills with others in a team environment.
6. Have acquired skills in computerized calculations

Settings, options, documents required:

1. Activate PASHA ACCESS PASHA MUST BE ACTIVE,then bring the file
2. ALL QUESTIONS WILL BE ANSWERED BY USING ORIGINAL NETWORK EXCEPT WHERE IT IS ASKED TO CONTINUE PREVIOS QUESTION
THE USER CAN RETERIVE THE FILE FOR EACH QUESTION, IF IN DOUBT ANYTHING HAS CHANGED WITH THE TOPOLOGY OR DATA OF
THE PRESENT NETWORK
3. FAULT ANALYSIS MUST BE USED
4. IN SOME QUESTIONS FAULT FROM LOAD FLOW MUST BE SELECTED
5. IN FAULT OPTIONS FAULT TIME MUST BE SET
6. READING FAULT MANUAL IN PASHA WILL BE HELPFUL
7. INTERNET MUST BE AVAILABLE
8. YOU ARE ADVISED TO READ THE LAB FILE POUYA POWER SYSTEM LAB.; WHAT ARE THE REQUIRMENTS?

2- Assign from the **FULL LIST** the connection type of transformer GHAEN-GHA1.

- ○ DX0
- ○ XD0
- ○ XD11
- ○ DX11

3- Use the **FLT Flows** and make a fault at buses shown on Table1. How much is the SCC at these busbars:

Table 1 SCC (MVA)

NEISH1	GONAB	SOLTAN

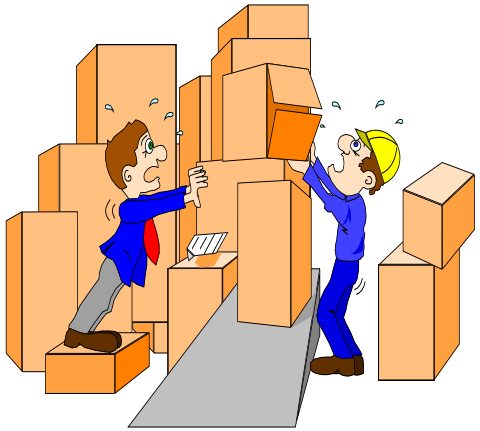
-How much is the Thevenin equivalent impedance from the SOLTAN view?

R (p.u)	X (p.u)	Z (Ohm)

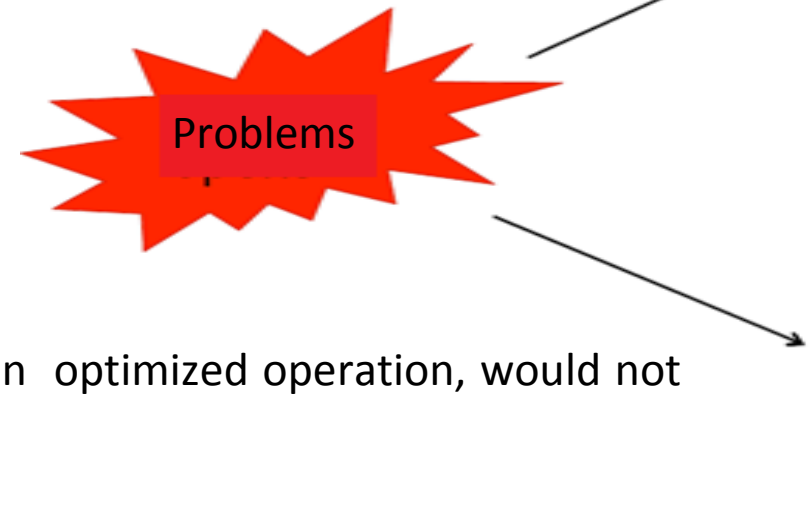
Make sure it is correct by doing hand calculation.

Examples of the problems

Despite all the efforts have been carried out for protecting and so securing the power system operation we see many difficulties in operation of the power systems due to mal-operation or miscoordination of the protection systems technically. Economically optimum operation of the entire power system including those related to the manufacturers has not been obtained so far.



In other word: The system hidden errors will be unveiled when an event goes in the direction that would not be expected or the system is not designed for.



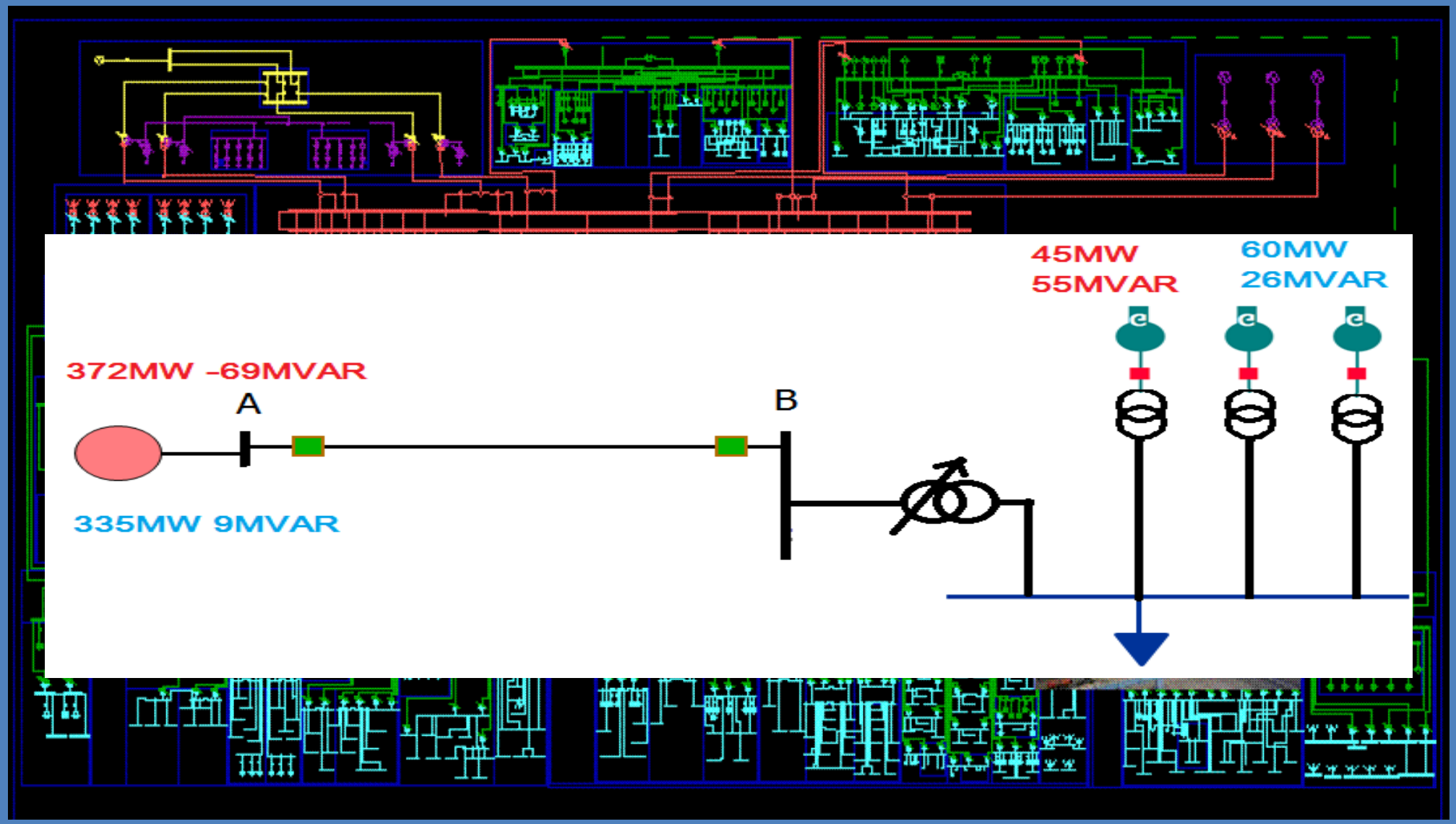
Power system operation already has many difficulties. By addition of the new incomers like wind and photo voltaic it is going out of control.

System that is not performing in optimized operation, would not show itself at all.

http://www.tomcad.com/linkedin/POUYA.BAT

POUYA.lnk

Increasing the local generators MW output



We all know:

The problem in actual interconnected power system is more complicated:

- Not only the exact models of our main equipment including the protection systems must be considered, but also the dynamic of the loads must be taken into account.
- The dynamics of all controllers must be included.
- It would be much larger and **more complex** than the current networks.

The complicity of the problem will be increased in the future since:

- The future of power grids would be **smart grids** enhanced by several types of advanced tools which supply different types of customers;
- It would be a combination of multi-Micro Grids or even **multi-Nano Grids**;
- It would be much larger and **more complex** than the current networks.

http://www.tomcad.com/linkedin/POUYA.BAT

Coverage

Although POUYA may seem to be a great help in designing and operation of power systems, the problem is: **I do not have any feedback from the actual operation of the plant.**

For example in the refinery plant maximum loading were used in the plant. However, this is not the case in an actual plant.

Regarding this, there would be four ways to correct the analysis:

1- Putting exact load profiles. This is not possible since load is changing during the operation.

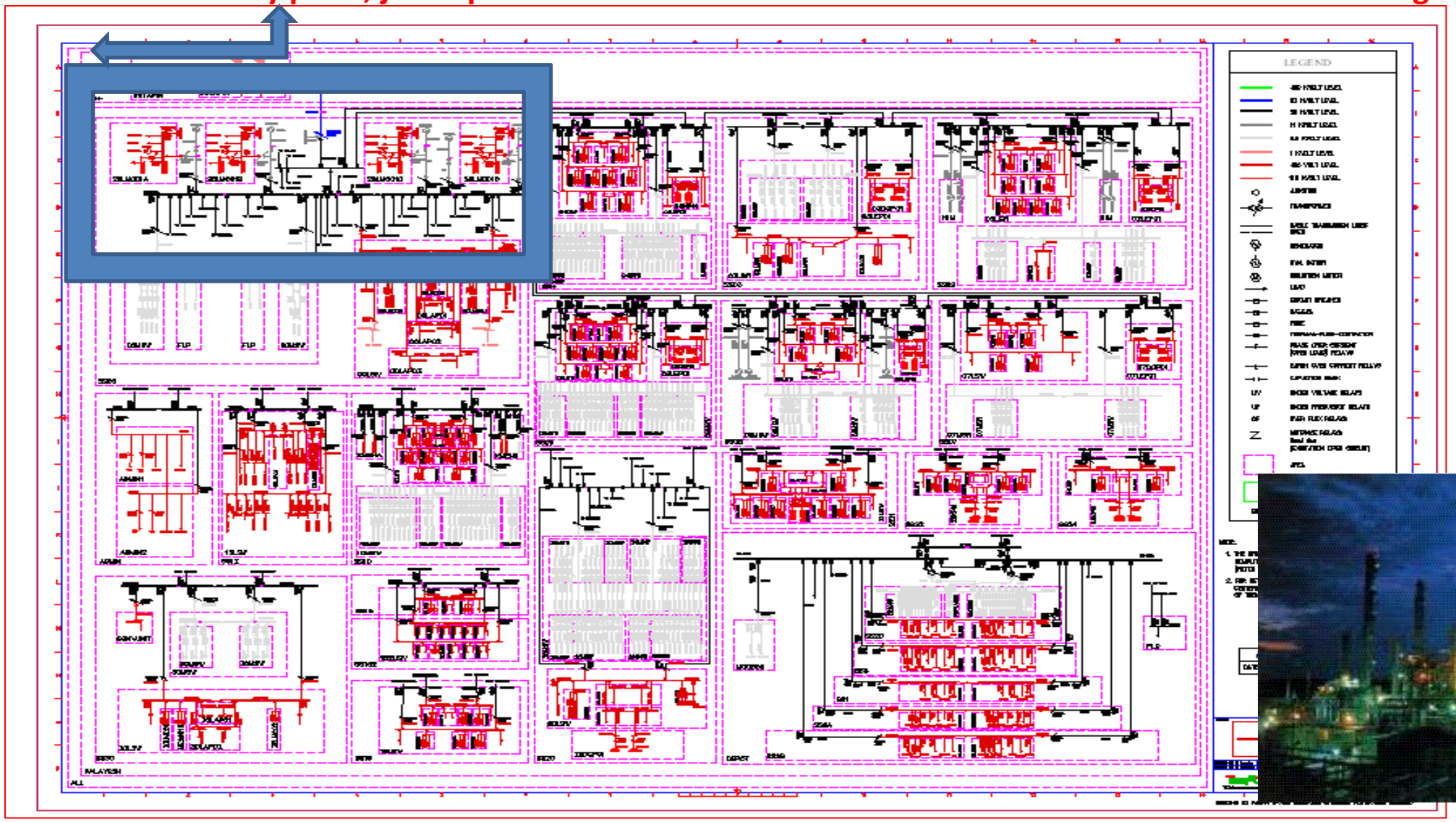
2- Use SCADA system. No SCADA can monitor all the signals coming from such large scale plants in a central control room.

3- Use predefined load changing scenario. This is good for the plants that their loads are changing periodically.

4- Estimate the plant loading condition using the SCADA system

Estimate the plant loading condition using the SCADA system

In this refinery plant, just a portion related to the main substation are available for monitoring in control room.



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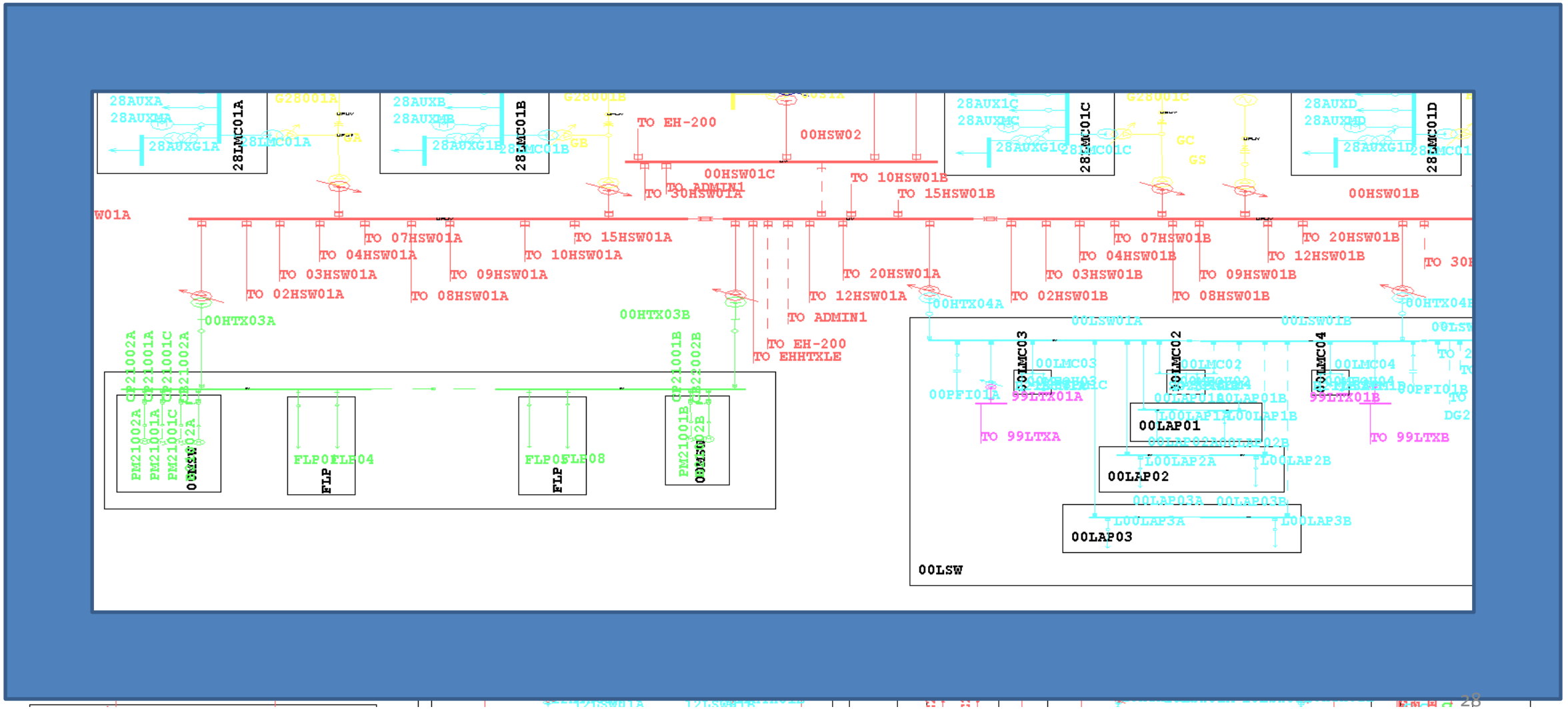

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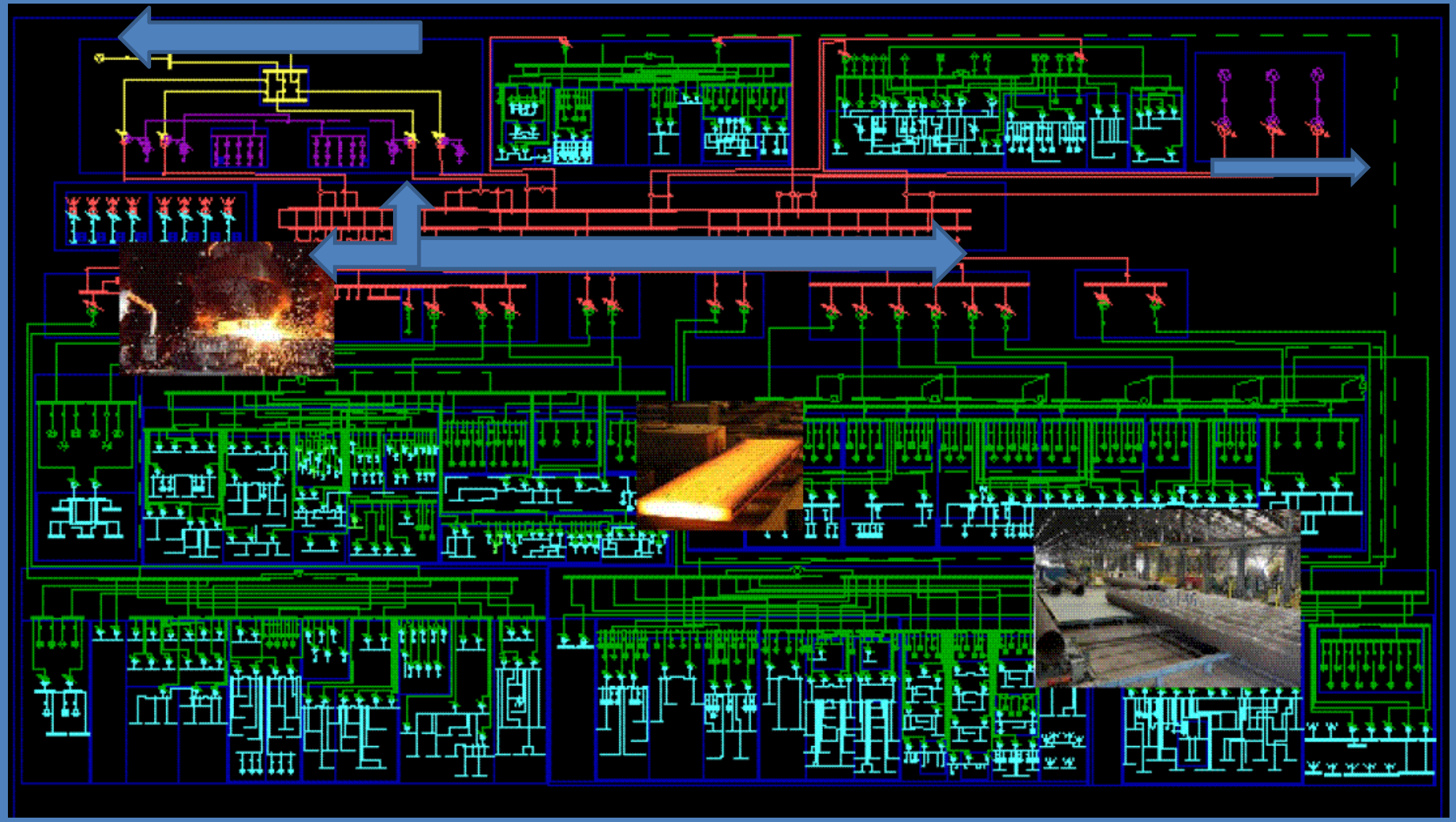

In this steel mill plant, just a portion related to the main substation are available for monitoring in control room.

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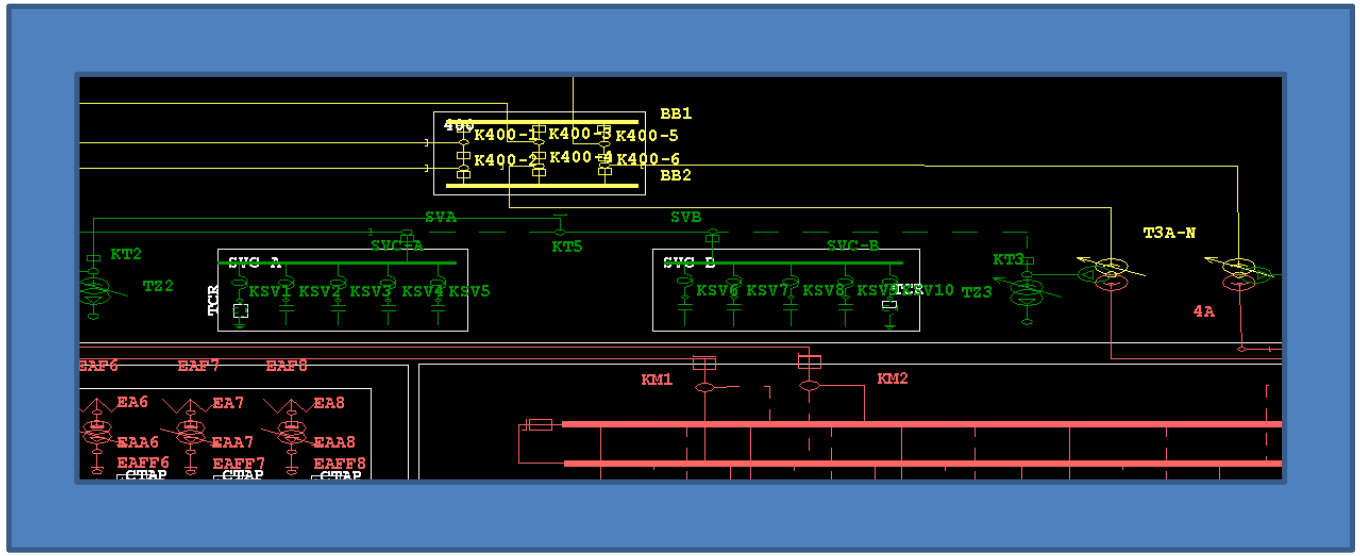
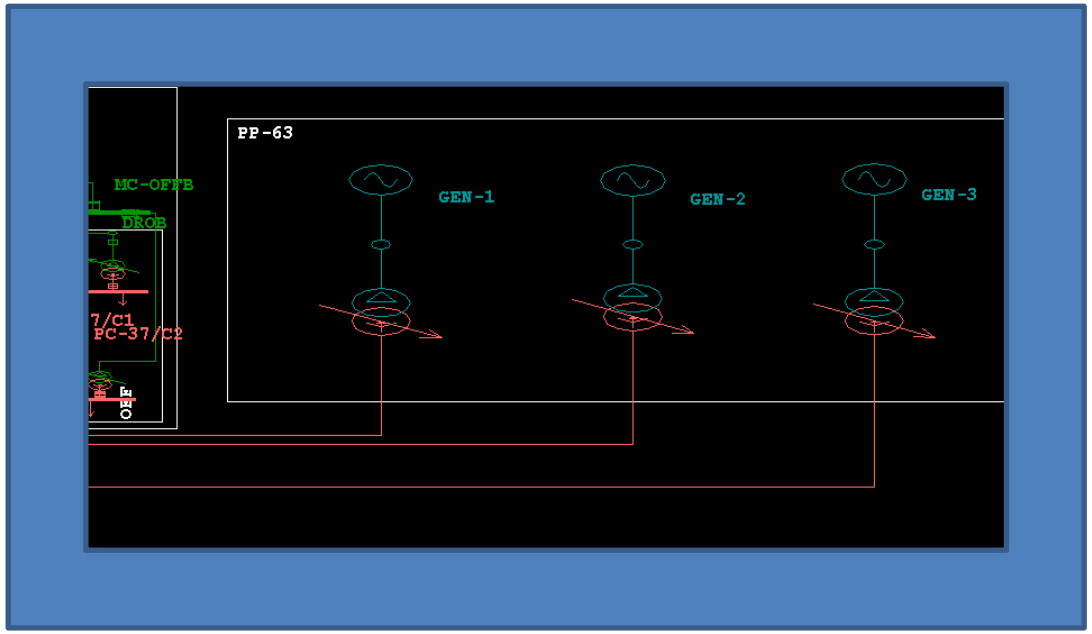
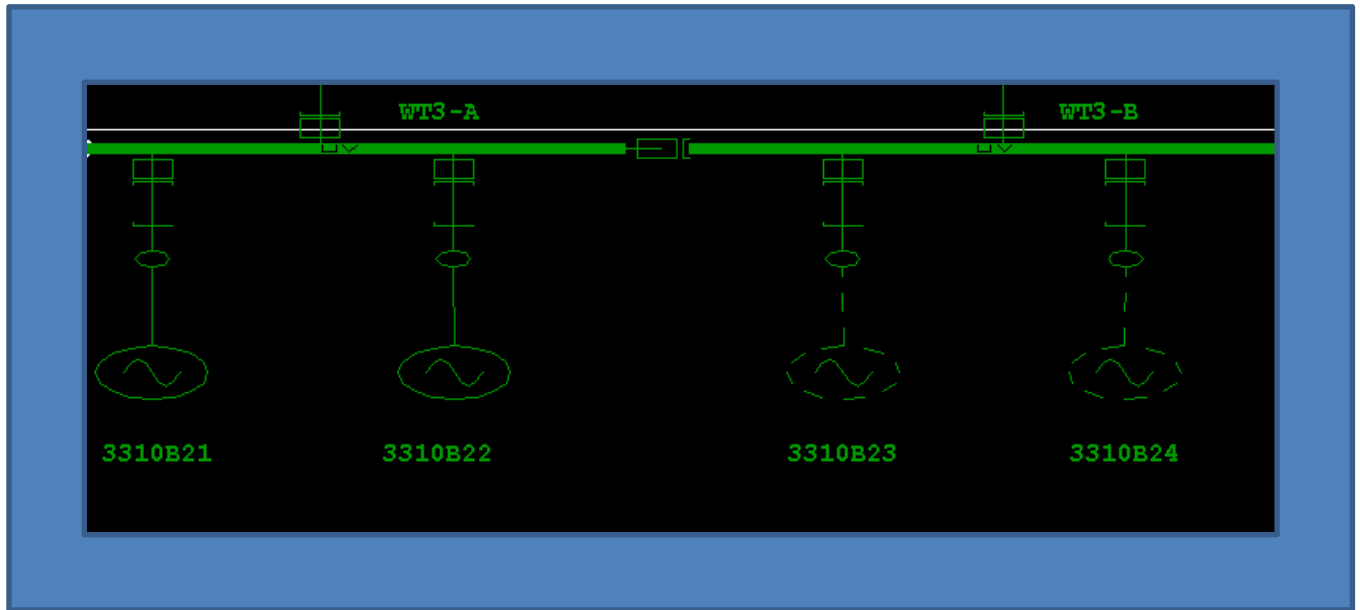


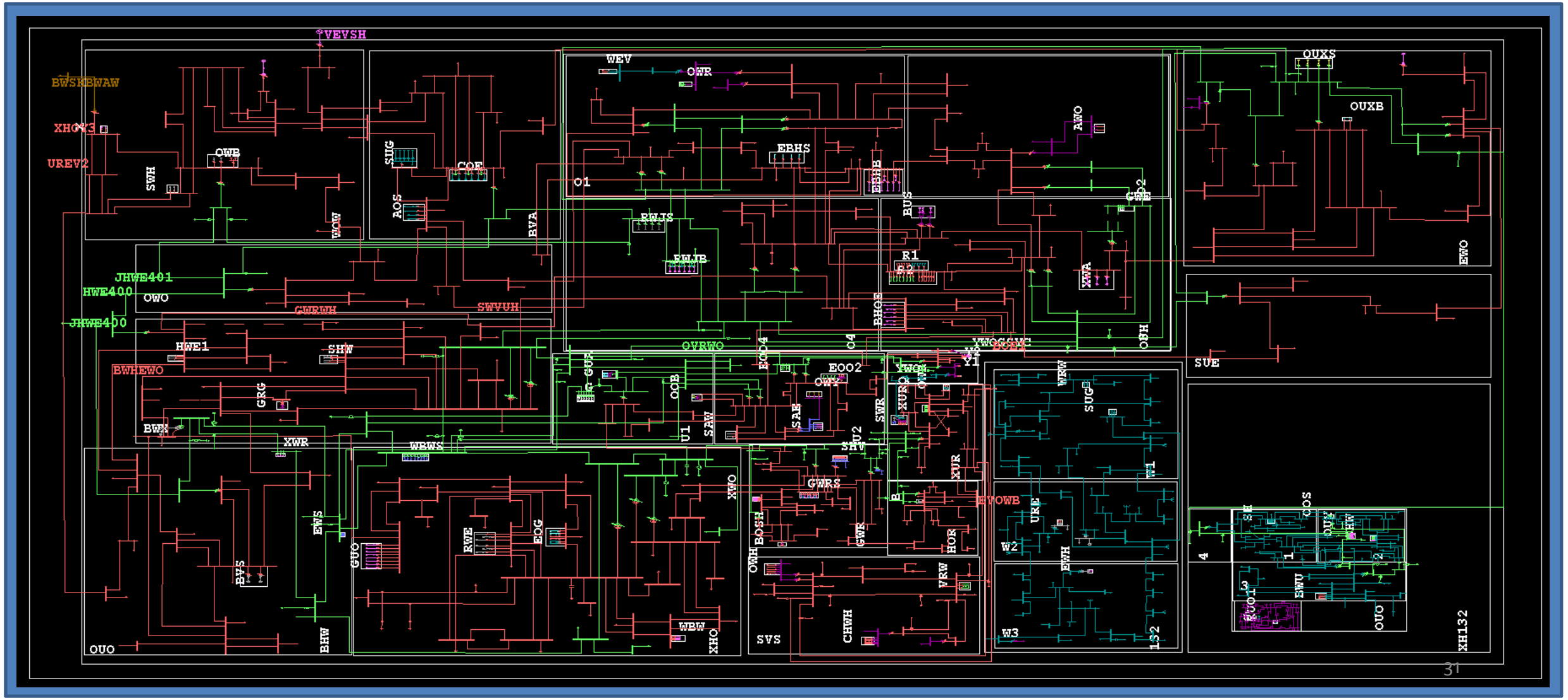




In this steel mill plant, just a portion related to the main substation are available for monitoring in control room.

Estimate the plant loading condition using the SCADA system

An interconnected network 400kV-230kV-132kV-63kV(just a small portion), and generation stations



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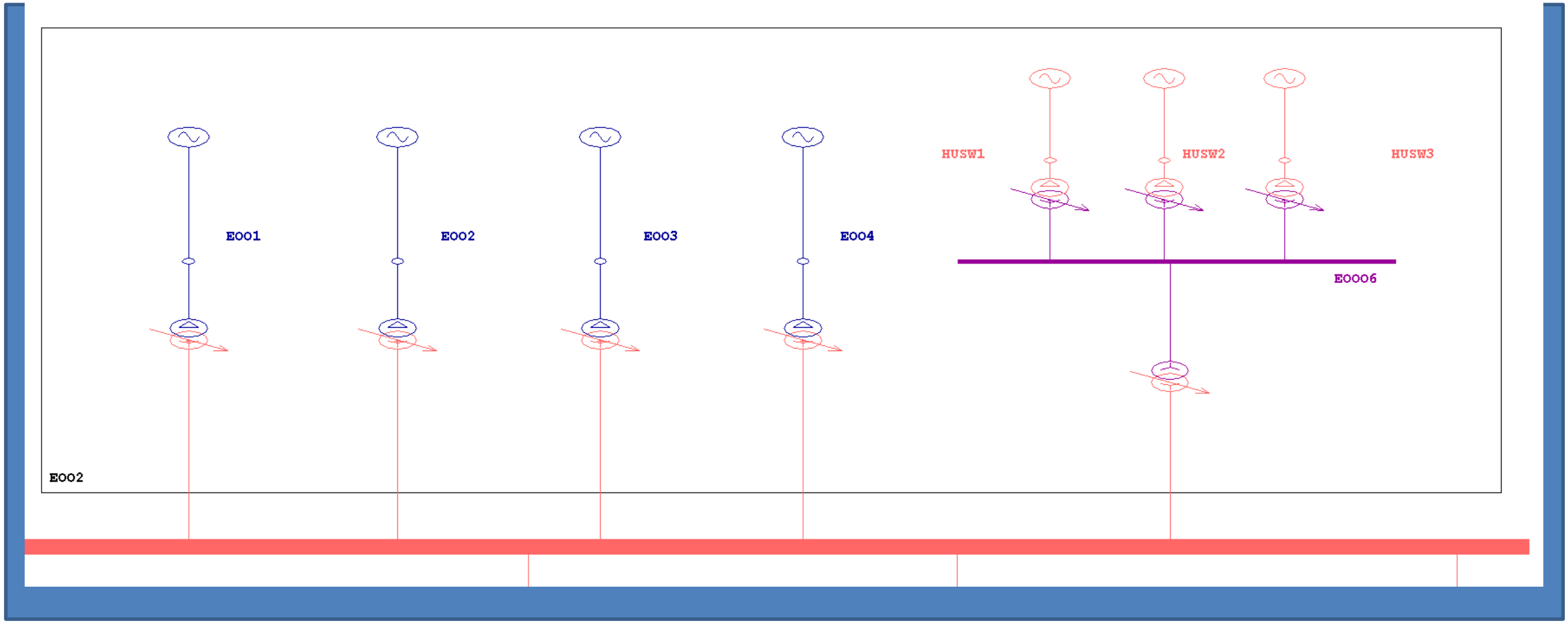
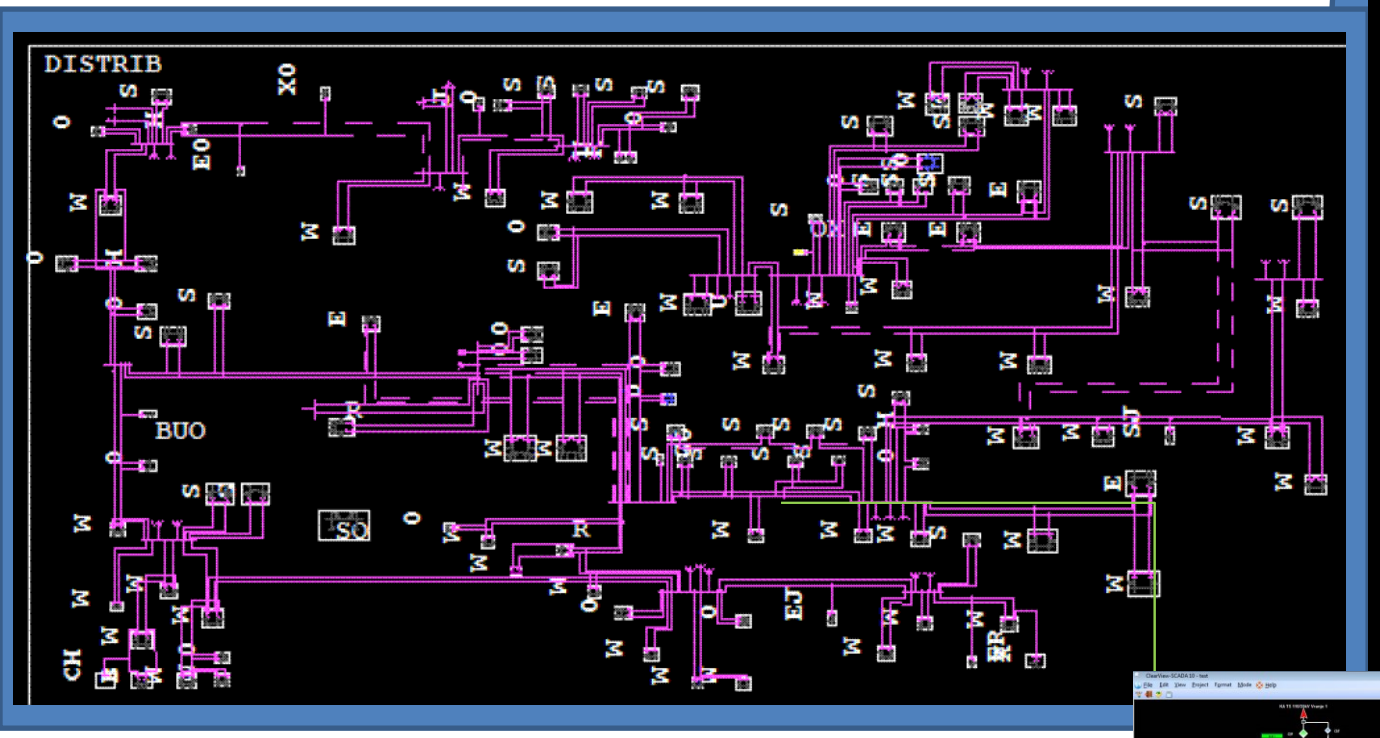
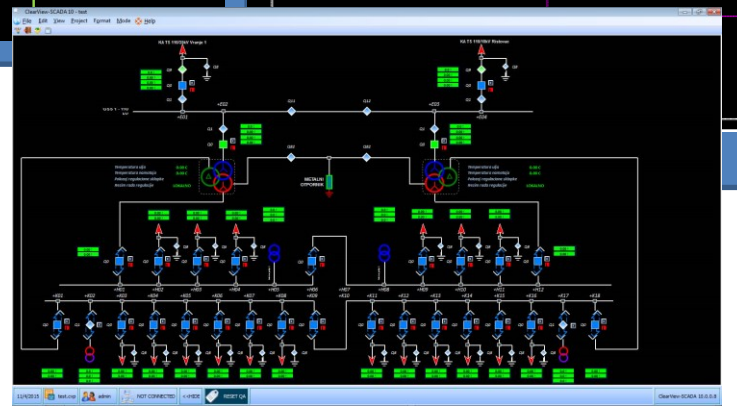


One of the generation station: 15.75kV-11kV-63kV-230kV

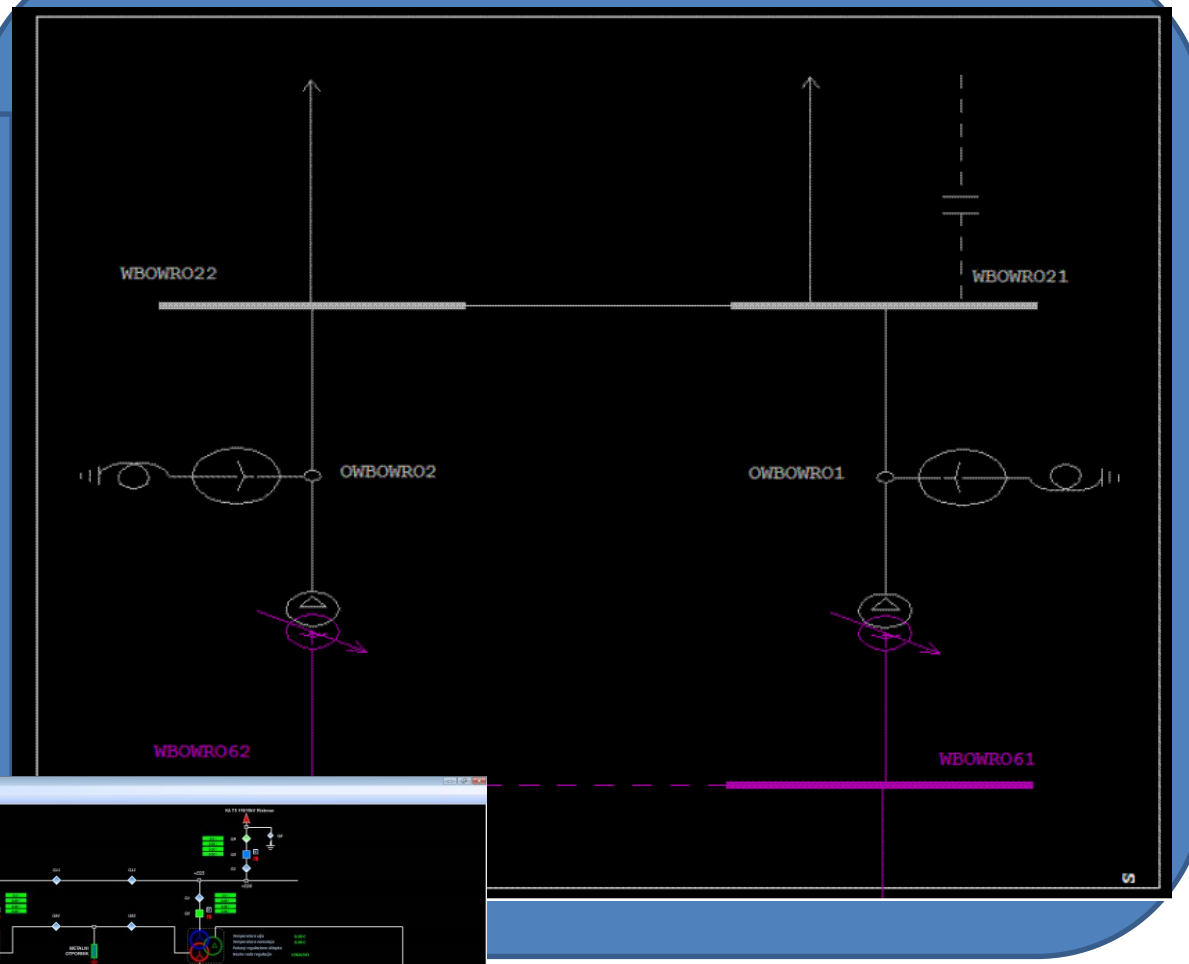
Estimate the plant loading condition using the SCADA system



63 kV/20 kV network of a distribution system Esfahan sub division from an interconnected grid.



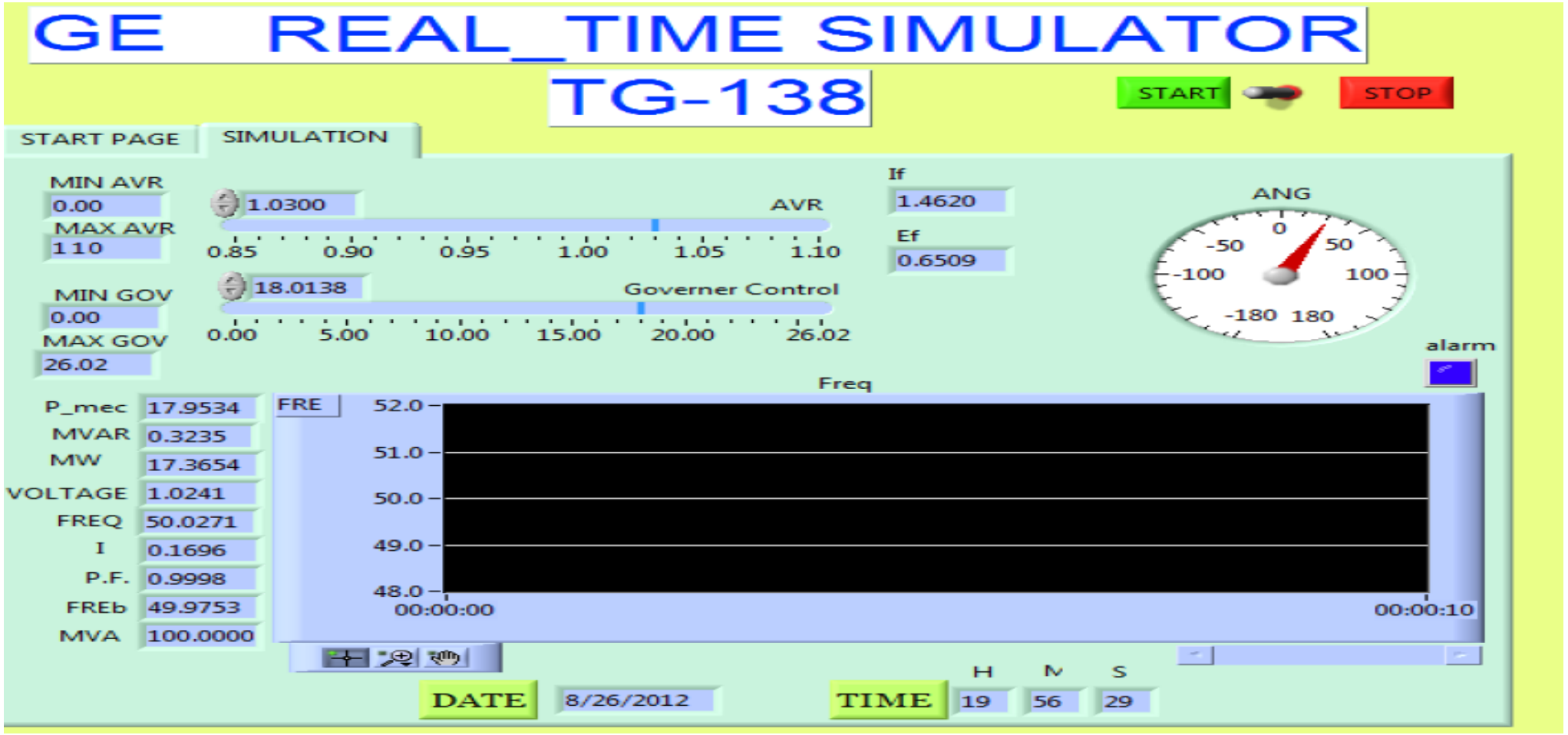
SCADA Monitoring



63 kV/20 kV substation.

On line or hard ware in the loop simulation

It means that the plant are connected to our simulator and so the computer knows the exact operation condition of the plant.



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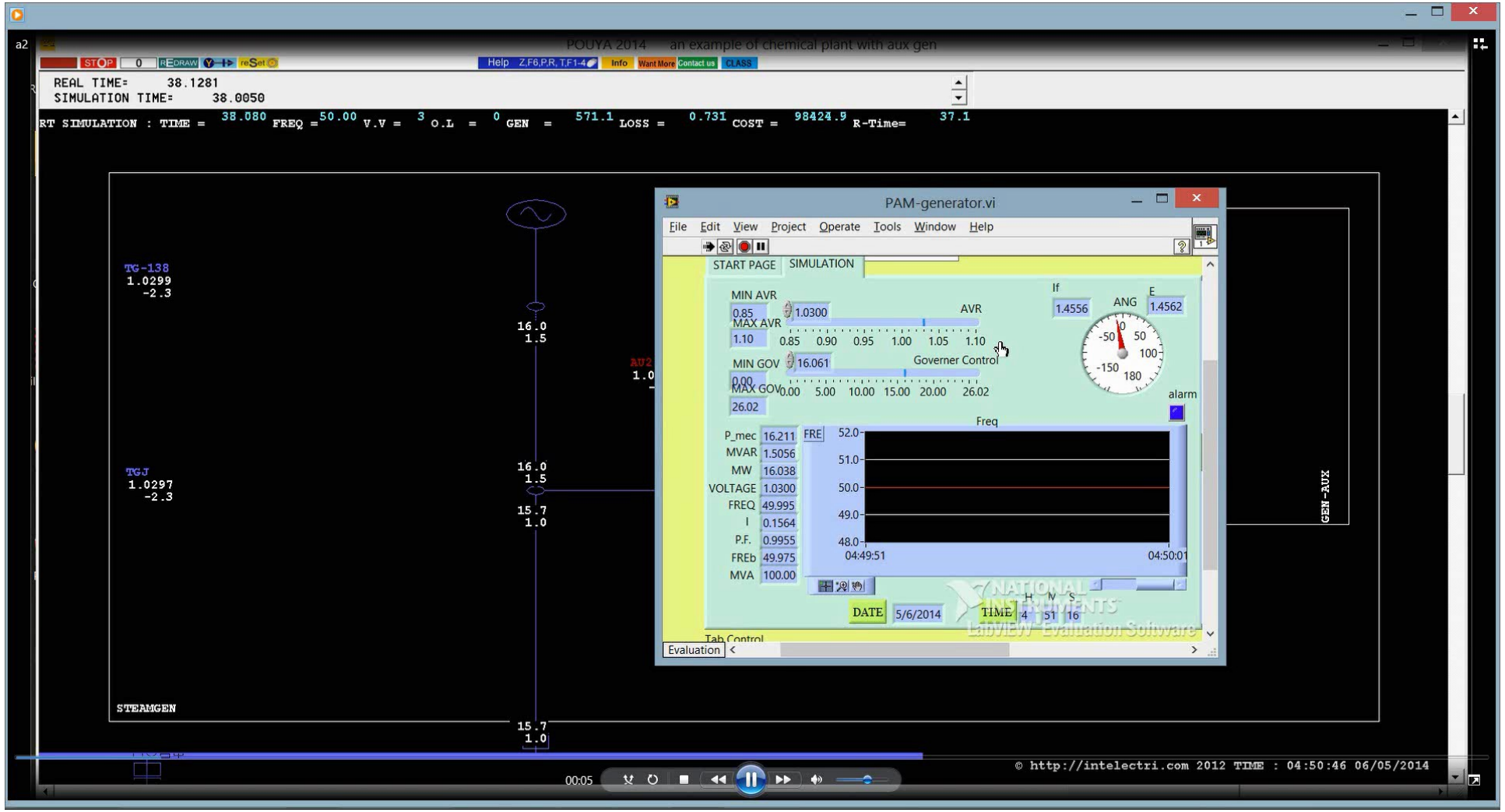
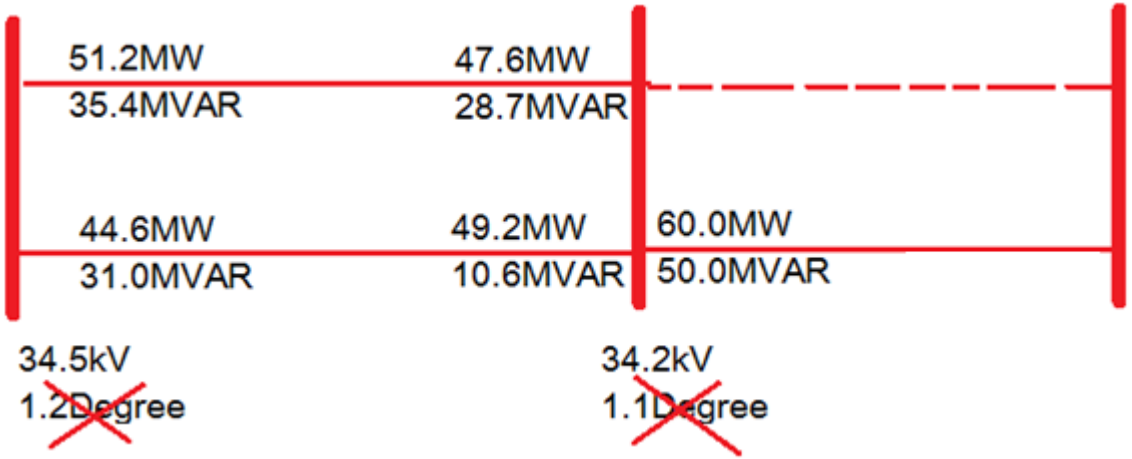
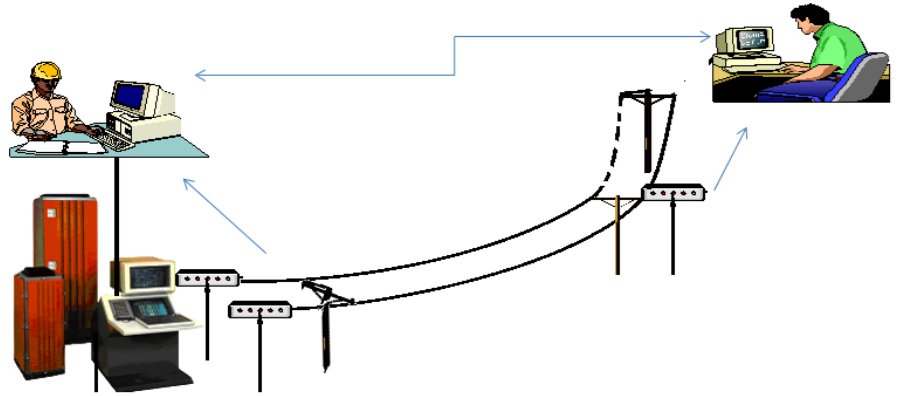
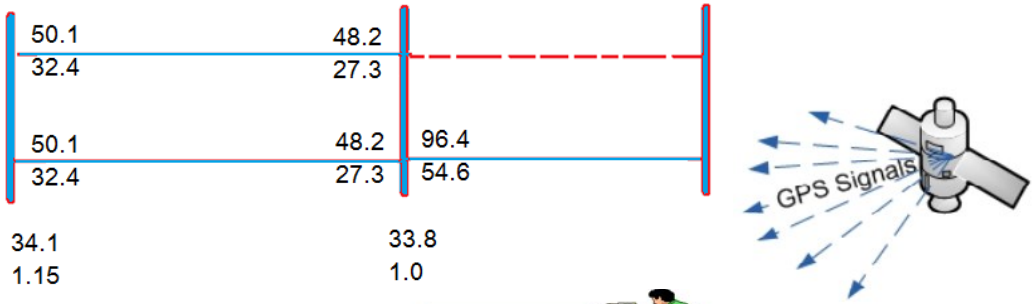


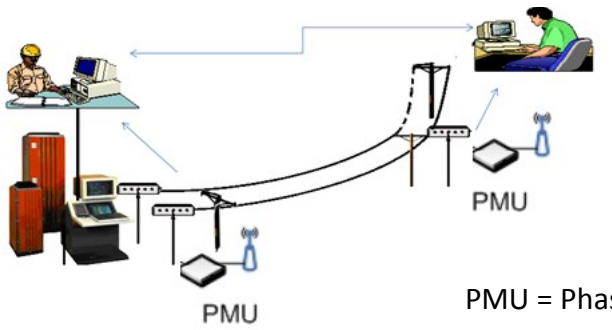
Binging data to a central control room has problem – it has delay errors

Example of monitoring on SCADA (exaggerated)









Obviously the values do not show the correct situation of the system, there are errors in the data where we are monitoring:

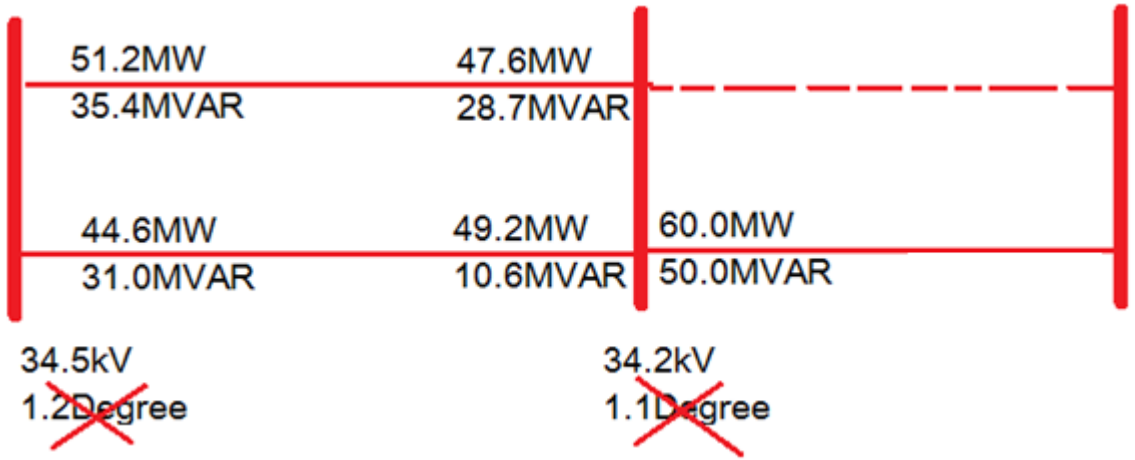
1- Inherent errors of RTUs

2- The values are not belong to one instant of time, because of possible delays involved. Time tagged values might be one of the solution, but it needs synchronization between RTUs, which can only properly be done through GPS system.

PMU = Phase Measurement Unit

Another problem with SCADA – Not all required values; measured

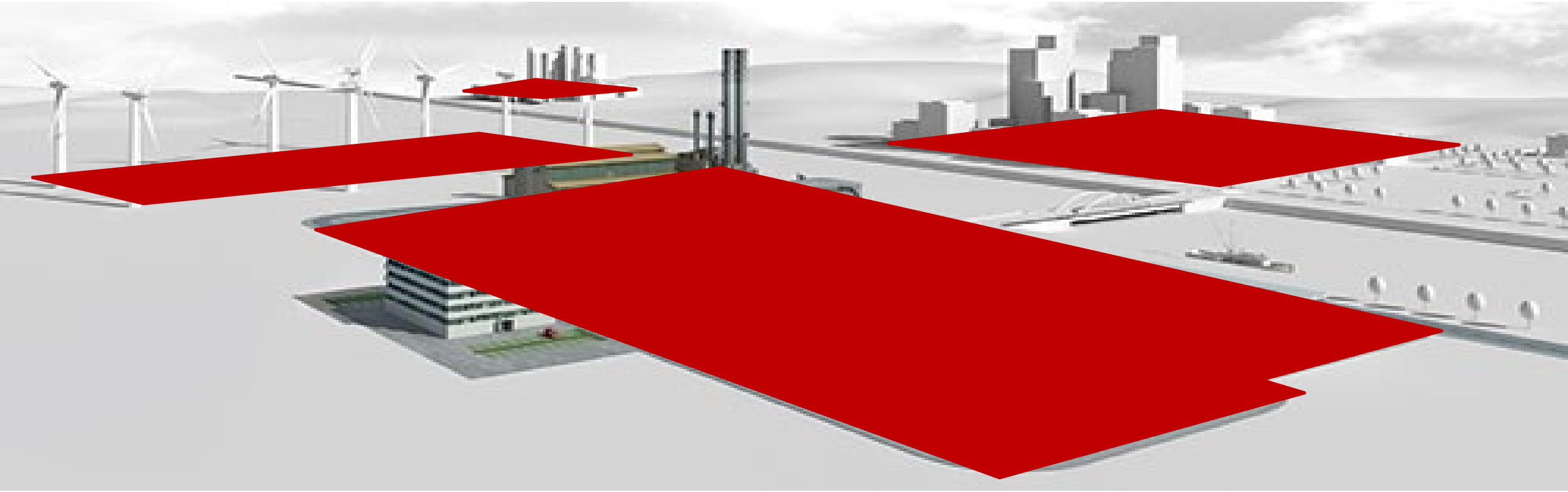
In previous example the receiving end of one of the lines data is not available.



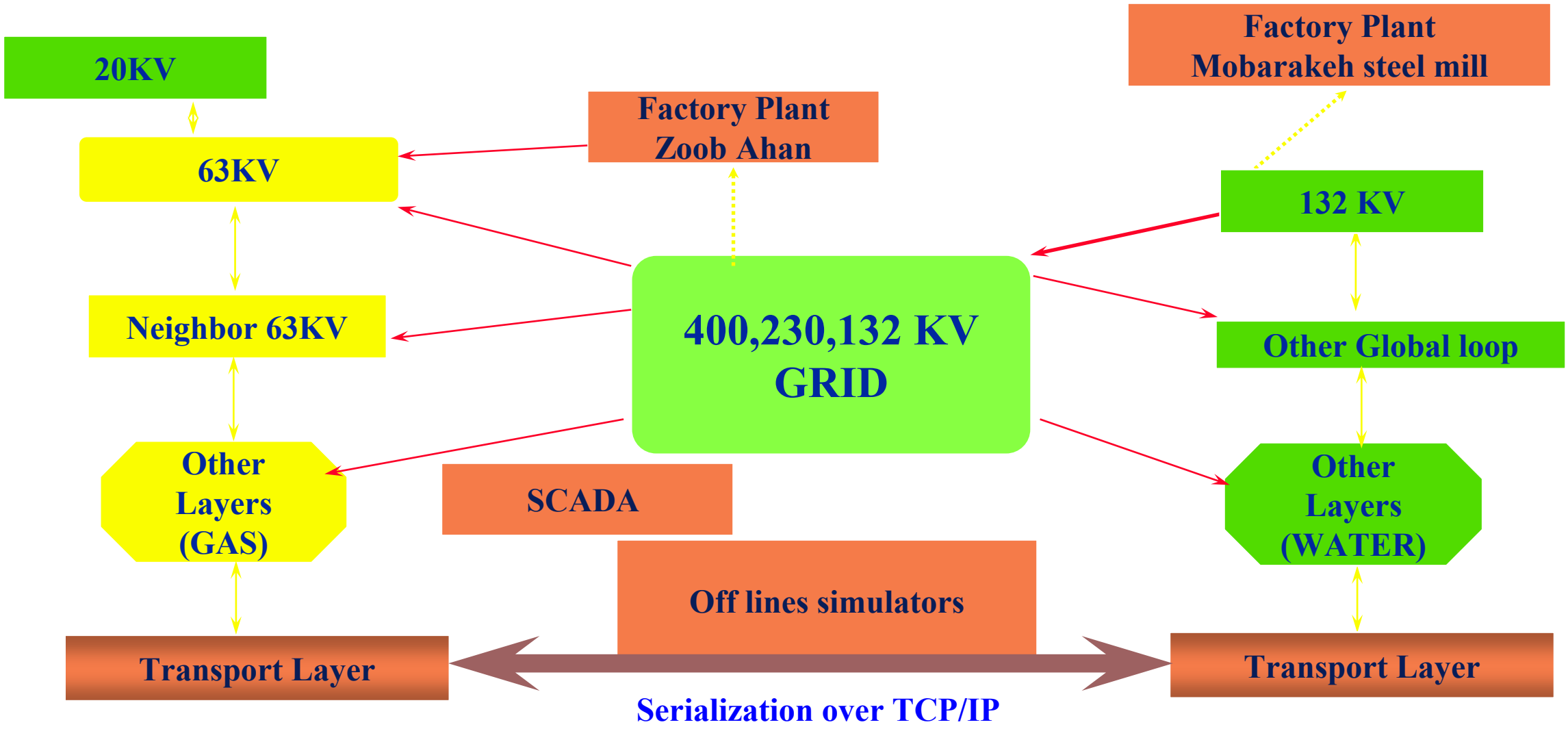
DCS in large factories just shows some high voltage substations and some important drives.

Global Network Simulation (GNS)

Decentralized Network Simulation



GNS divides the task of simulation

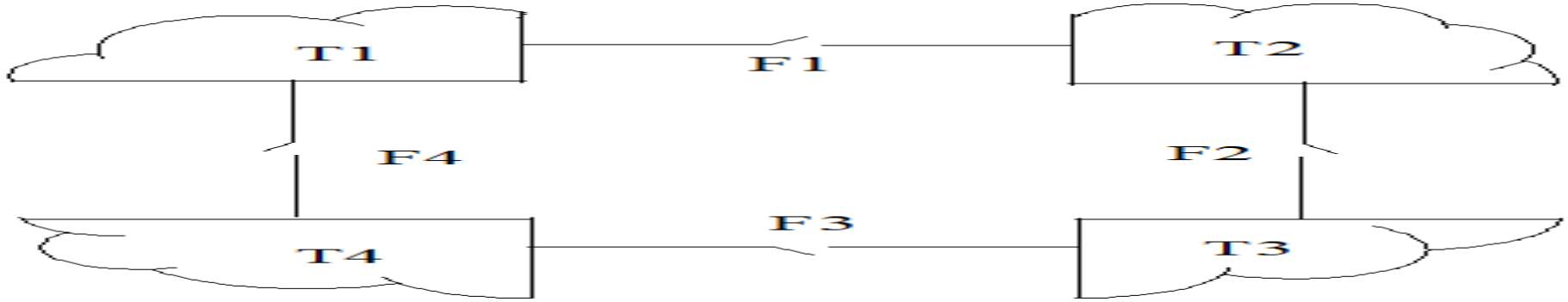


Global Network Simulation

Global Network Simulation (GNS)

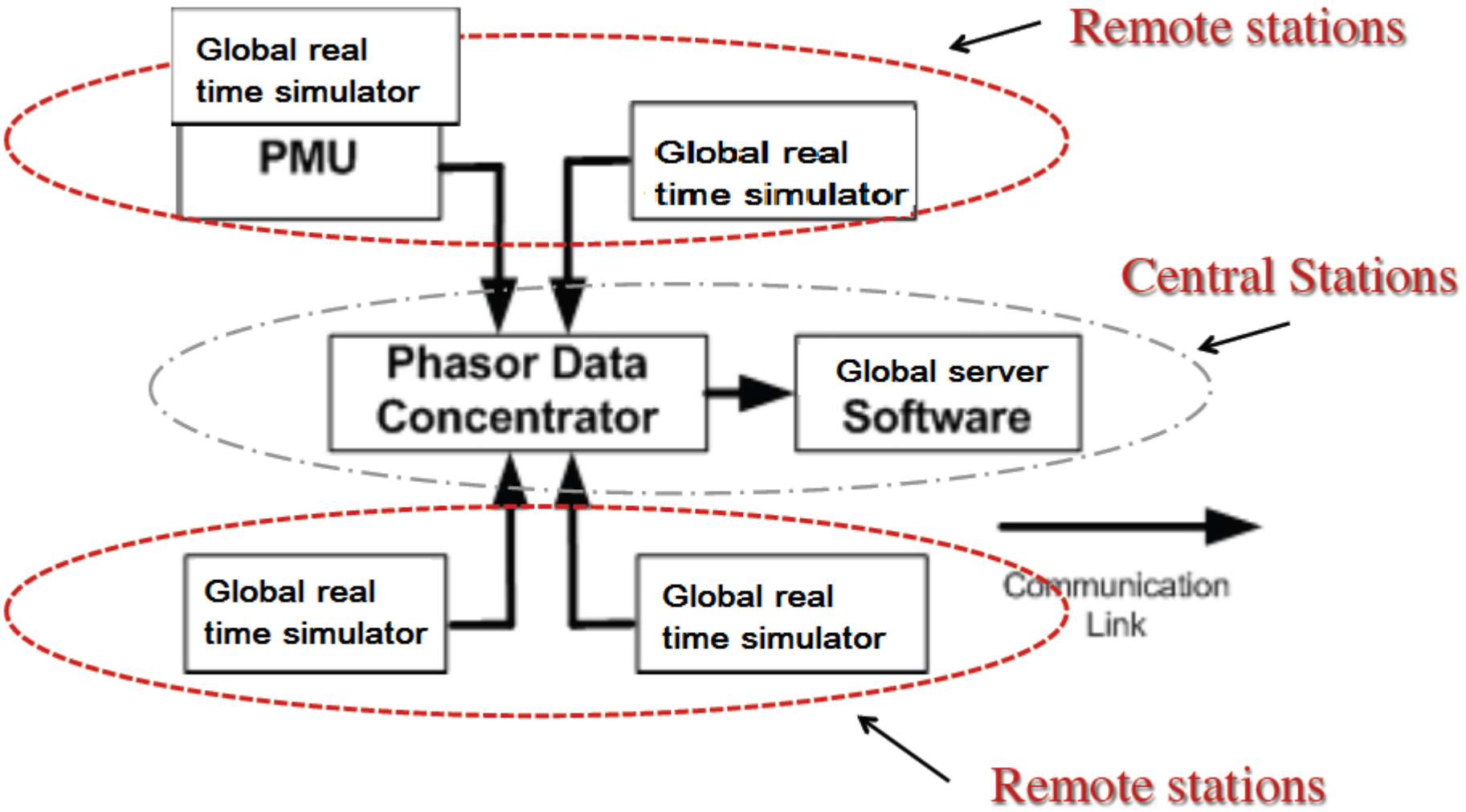
1. Break an interconnected power system into ***n*** distinct parts;
2. Conduct the load-flow/fault/transient-stability/real time simulation. in each of this parts separately;
3. **But**, Get the **same solutions** as those of the **interconnected** one!

This can be simply done by LCS method, where it is a sub-calculation of Diacoptic method.



The Interchanging data are so small. Less than 100 bytes at the border busbars

Using computerized operation



+ Control Functions

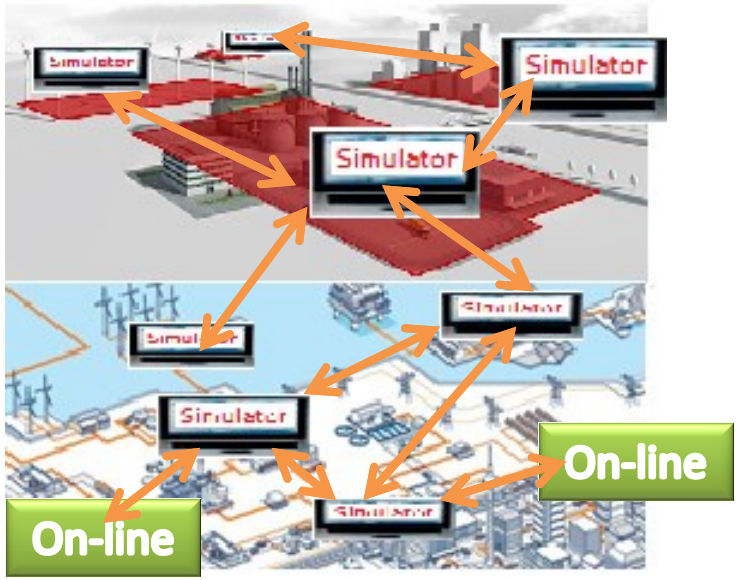
Using computerized operation

Here it is shown what computerized capability will be required to follow the road map.

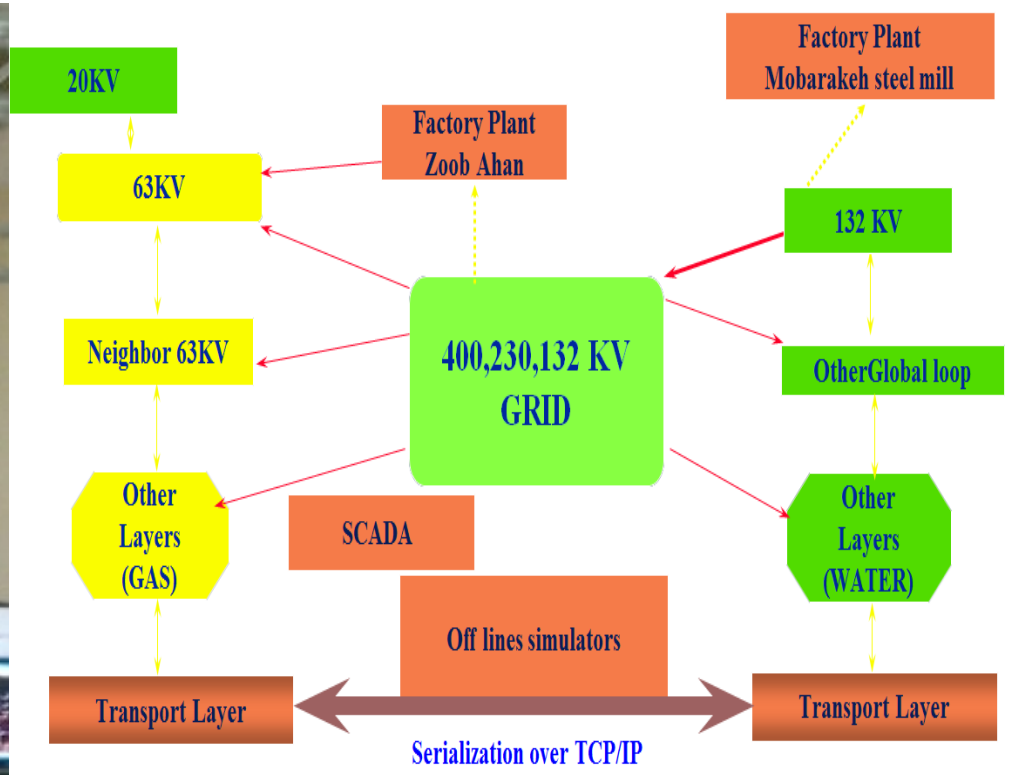
Real Time Simulation

On Line Simulation

Global Network Simulation



POUYA Simulates Global Networks of more than 10000 busbars



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Some of the advantages of using POUYA :

With Online Simulation, not only can you perform all analysis you need using real-time simulation, you can also simulate “what if” scenarios simply by taking real time action.

The user can control the simulation process even deep inside the power system controllers like AVR and Governors

POUYA is the fastest simulator you can find around.

By using POUYA power system engineers can forget about many standard calculations like (Load Flow, Fault analysis, providing Scenario for transient stability) they have learned so far because they have all in real time simulation on their desk.

Most software has a big manual for the users. To use the features of that particular software the users need to read most of these manuals. For using POUYA you do not need to read a book.

It just needs to refer to a 11 pages quick manual to use the most advanced power system simulator.

Global Network Simulation - Publications

We have started to do Global Network Simulation:

2000	• Load Flow and Fault analysis are done in GNS;
2005	• Transient Stability is done in GNS.
2010	• Real time simulation has started.
2010	• GNS has expanded for real time simulation
2012	• All the controllers and protections have added to the real time simulation.
2015	• Dynamic optimization is running. Real time security assessment is under way. • GNS real time harmonic calculation has done

Global Network Simulation- Publications

Iranian Journal of Science & Technology, Transaction B, Engineering, Vol. 29, No. B4
Printed in The Islamic Republic of Iran, 2005

A DISTRIBUTED COMPUTING APPROACH FOR POWER SYSTEM ANALYSIS*

A. KALANTARI** AND S. M. KOUHSARI
Dept. of Electrical Engineering, Amirkabir University of Technology, Tehran, I. R. Iran

EUROPEAN TRANSACTIONS ON ELECTRICAL POWER
Euro. Trans. Electr. Power 2010; **20**:845–861
Published online 18 June 2009 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/etep.363

An adaptive distance relaying strategy based on global network simulation

V. Gohari Sadr*,† and SH. M. Kouhsari
Department of Electrical Engineering, Amirkabir University of Technology (AUT), 424 Hafez Avenue, Tehran 15875-4413, Iran

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Available online at www.sciencedirect.com
ScienceDirect
Electric Power Systems Research 77 (2007) 673–684
ELECTRIC POWER SYSTEMS RESEARCH
www.elsevier.com/locate/epsr

A distributed simulation based approach for detailed and decentralized power system transient stability analysis

S. Esmaeili *, S.M. Kouhsari
Department of Electrical Engineering, Amirkabir University of Technology (AUT), 424 Hafez Avenue, Tehran 15875-4413, Iran

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Electrical Power and Energy Systems 30 (2008) 216–225
ELECTRICAL POWER & ENERGY SYSTEMS
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An exact piecewise method for fault studies in interconnected networks ☆

Amir Kalantari *, Shahram Montaser Kouhsari [1]
Department of Electrical Engineering, Amirkabir University of Technology, 424 Hafez Ave., Tehran 15914, Iran

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Amir Kalantari *, Shahram Montaser Kouhsari [1]
Department of Electrical Engineering, Amirkabir University of Technology, 424 Hafez Ave., Tehran 15914, Iran

Other related Publications

[20] S. Esmaeili, S. M. Kouhsari, “A Distributed Simulation Based Approach for Detailed and Decentralized Power System Transient Stability Analysis”, Electric Power System Research, 2007; 77, 673-84.*

[21] B. Hashemi, S. Montasser-Kouhsari, G.B. Gharehpetian, “A New Approach for Modeling of Multiterminal DC System in Load Flow Programs” IFAC Symposium on Power Plants and Power Systems Control 2003, Sep. 15-18, 2003, Seoul, Korea

[29] V. Gohari Sadr, S. M. Kouhsari, “An adaptive distance relaying strategy based on global network simulation” Digital Object Identifier (DOI) 10.1002/etep.363* European Transactions on Electrical Power

[30] M. Tajdinian, M.Z. Jahromi, K. Mohseni, S.M. Kouhsari,
“An analytical approach for removal of decaying DC component considering frequency deviation,” *Electric Power Systems Research*, Jan. 2016.

[31] Amangaldi Koochaki, Shahram Montaser Kouhsari ”Simulation of simultaneous unbalances in power system transient stability analysis”. Simulation 87(11): 976-988 (2011)

Last but not least: Interfacing Transient Stability and Extended Harmonic Domain for Dynamic Harmonic Analysis of Power Systems, Coming in IET journal

Innovation on software development

Calculating DC offset in a phasor based transient stability program

Inclusion of DC machines

Three phase transient stability

Analysis of faults inside components

etc……..

Thanks for Taking Part and Your Attention

Special thanks to the organizers of the Seminar:

Ir Dr. Edward Lo, this **would not** have **happened without him**

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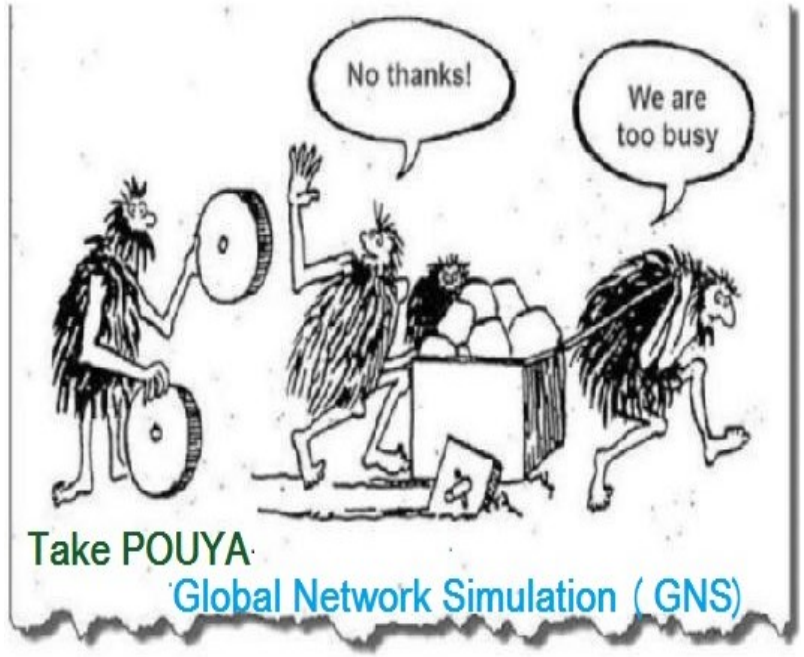

Innovations are usually not quickly understood and accepted

Questions?