TUTORIAL – SESSION 1
IMPLEMENTATION OF THE VRP PROBLEM
(VEHICLE ROUTING PROBLEM)

SESSION 1: INTRODUCTION

OPTΣX Mathematical Modeling System

SEMINAR:
TÉCNICAS AVANZADAS DE OPTIMIZACIÓN PARA EL SECTOR PETROLERO

PROMOTORS:

PEMEX

DECISIONWARE
MAKING YOUR WORLD SMARTER

ITAM INSTITUTO TECNOLÓGICO AUTÓNOMO DE MÉXICO
EXCELENCIA ACADÉMICA

PARTICIPANTS:

CAPD CENTER

IBM

IMP INSTITUTO MEXICANO DEL PETRÓLEO

D Analytics

ipt INSTITUTO DE PESQUISAS TECNOLÓGICAS

INDUSTRIALGORITHMS
Solving Complex Supply & Production Chain Planning and Scheduling Problems

Invited Speaker:

Professor Ignacio Grossmann, Ph. D.
Center for Advanced Processes Decision-making (CAPD)
Carnegie Mellon University

Date: February 5th ,2016
Time: 9:00 am a 5:00 pm
Place: Auditorio ITAM, México D.F.
Attend: Personal Invitation

Request of invitation:

Detailed program: PDF DOWNLOAD

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OPTIMIZATION SOLUTIONS FOR OIL & GAS

	Decision Horizon	UPSTREAM EXPLORATION & PRODUCTION: Explore, Produce, Trade	Transport	MIDSTREAM REFINING & CHEMICALS: Store, Refine, Store	DOWNSTREAM MARKETING & SERVICES: Distribute
Strategic	Years	▪ Project & Budget Planning ▪ Staff Budgeting ▪ Inventory Budgeting and Positioning ▪ Delivery Planning ▪ Maintenance Planning ▪ Network Design and Sourcing	▪ Pipeline Network Design ▪ Sourcing ▪ Rail Fleet Sizing ▪ Vessel Fleet Sizing ▪ Long Term Purchasing	▪ Plant Sizing and Sourcing ▪ Long Term Production Planning ▪ Purchase & Storage Planning	▪ Pipeline Network Design ▪ Sourcing ▪ Rail Fleet Sizing ▪ Vessel Fleet Sizing
Tactical	Quarters, Months	▪ Project Planning ▪ Maintenance Scheduling ▪ Technician Planning ▪ Production Planning ▪ Trading and Risk Management ▪ Oil Blending	▪ Vessel Planning ▪ Rail Planning ▪ Empty Car Management ▪ Spot Cargo Management ▪ Trading	▪ Production Planning ▪ Inventory Planning	▪ Distribution Planning (vessel, rail, truck)
Operational	Weeks, Days, Hours, Minutes	▪ Project Scheduling, Monitoring and Rescheduling ▪Technician Dispatching ▪ Inventory Assignment ▪ Resources Allocation	▪ Berth Allocation ▪ Pipeline Scheduling ▪ Vessel Scheduling ▪ Rail Scheduling ▪ Staff Scheduling	▪ Refinery Planning and Blending Scheduling ▪ Production and Outbound Logistic Scheduling ▪ Pipeline Scheduling	▪ Berth Allocation ▪ Vessel Scheduling ▪ Rail Scheduling ▪ Truck Routing ▪ Vendor Management Inventory

Source: IBM

ICORD 2016

DOA invited you to visit http://ifors.org/icord2016/ and to participate in ICORD 2016 that will be held on June 9-10, 2016 at the facilities of Instituto Tecnológico Autónomo de México (ITAM) in México City.

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OPTEX Mathematical Modeling System

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OBJECTIVE

The purpose of this tutorial is oriented to show to the reader, from scratch, step by step, the implementation of an optimization problem using OPTEX. This implementation is performed in two steps:

1. **Implementation of the model in OPTEX-EXCEL-MMS.**
   - **Implement, in an empty template of OPTEX-EXCEL-MMS, the mathematical model**
   - **Solve the problem associated with the mathematical model using OPTEX-WEB**
   - **Solve the problem associated with the mathematical model using OPTEX-EXCEL-MMS**

2. **Implementation of the model in OPTEX-MMIS**
   - **Import the mathematical model from the template in EXCEL to OPTEX**
   - **Check the mathematical model using the services offered by OPTEX-GUI**
   - **Generate computer programs in C, GAMS and OPL-IBM technologies.**
   - **Load data from the VRP problem in an EXCEL template generated by OPTEX-GUI.**
   - **Solve the problem associated with the mathematical model using OPTEX-EXE.**

To perform the first process, the interested requires to have installed in his computer the components of OPTEX-EXCEL-MMS; for the second process is required to have installed a full version of OPTEX.

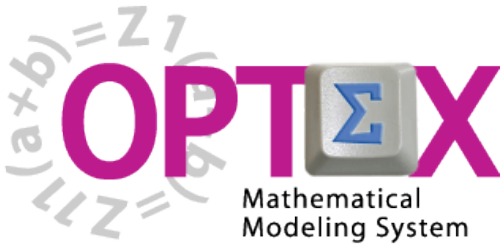
This tutorial is not intended to teach to formulate mathematical models of optimization and therefore not analyzed or discussed the validity of the formulation; the aim is that the user understands the steps to follow to implement a "simple" mathematical model in OPTEX-EXCEL-MMS and OPTEX-MMIS.

The tutorial document is divided into 13 sections/numerals and the presentation of the tutorial is considered it can be arranged in 8 sessions covering all the numerals, each session is linked to a presentation of "slides" (in English) in which the material is presented, and this presentation is associated with a video (this material will be released when it is available).

OPTΣX Mathematical Modeling System

TUTORIAL BASIC

1. **SESSION 1: INTRODUCTION**
   - Introduction to OPTEX (Section 1)
   - OPTEX-EXCEL-MMS (Section 2)
2. **SESSION 2: VRP MODELING IN EXCEL**
   - VRP: Vehicle Routing Problem (Section 3)
   - Implementing VRP Model using EXCEL (Section 4)
3. **SESSION 3: USING EXCEL TO LOAD DATA**
   - Industrial Data Information Systems –IDIS- (Section 5)
4. **SESSION 4: OPTEX-GUI – LOADING MODELS**
   - Loading the Model in OPTEX-MMIS (Section 6)
   - Verification of the Model in OPTEX-MMIS (Section 7)
5. **SESSION 5: Loading and Checking Industrial Data**
   - Implementation and Validation of IDIS- (Section 8)
6. **SESSION 6: Solving Mathematical Models**
   - Scenarios and Families of Scenarios (Section 9)
   - Solution of Mathematical Problems (Section 10)
   - Results Information System (Section 11)
7. **SESSION 7: SQL Servers**
   - Using SQL Servers for IDIS (Section 12)
8. **SESSION 8: Optimization Technologies**
   - Solving Problems using C (Section 13.1)
   - Solving Problems using GAMS (Section 13.2)
   - Solving Problems using IBM OPL (Section 13.3)



TUTORIAL
IMPLEMENTATION OF THE VRP PROBLEM
(VEHICLE ROUTING PROBLEM)

TUTORIAL
BASIC

1. SESSION 1: INTRODUCTION

- Introduction to OPTEX (Section 1)
- OPTEX-EXCEL-MMS (Section 2)

YOU CAN DOWNLOAD A FULL FREE OPTEX SPANISH VERSION
(IN SOME DAYS THE FULL FREE ENGLISH VERSION WILL BE READY)

PDF DOWNLOAD **Request an OPTEX License**

PDF DOWNLOAD **OPTEX Installation Manual**

PDF DOWNLOAD **OPTEX Manual de Instalación (spanish)**

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URL LINKS

OPTEX Mathematical Modeling System

OPTEX
Actual Index Presentation
(this document)

OPTEX
General Presentation
(English)

OPTEX
Page

@optex_mms

OPTEX
Users Group

OPTEX Descriptive

Spanish

English

OPTEX Tutorial VRP

Spanish

English
(in elaboration)

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THIS PRESENTATION CONTAINS LINKS TO DETAILS PRESENTATION FOR PRINCIPALS TOPICS

URL LINKS

OPTΣX Mathematical Modeling System

The **OPTEX** documents are available in two sources:

- Packaged file that is download during the installation process;
- Documents stored individually, these always correspond to the latest version of the document.

FILES TO DOWNLOAD
OPTEX-MMS: Installation
OPTEX-EXE: Actualization of Executables
OPTEX-VRP: Actualization VRPDSS Tutorial

URL LINKS

OPTEX Mathematical Modeling System

The individual files for download are presented in the following table, each file is associated with a hyperlink that allows you to download the latest version of the document from the web site of **www.doanalytics.net**.

OPTEX Manuals (in Spanish)
OPTEX Descriptivo General
OPTEX Instalación
OPTEX GUI-Usuario
OPTEX GUI-Administrador
OPTEX Usuario
OPTEX Administrador
OPTEX Administrador Validación de Datos
OPTEX Conectividad en Red
OPTEX Conectividad Tecnologías de Optimización
OPTEX Documentos RTF
OPTEX EXCEL-GUI Usuario
OPTEX EXCEL-MMS Usuario
OPTEX Lenguaje Algebraico
OPTEX Modelamiento del Sistema de Información SIDI
OPTEX Modelo de Datos SIMM
OPTEX Server Administrador
OPTEX Tutorial Implementación Modelo VRP
OPTEX Tutorial Implementación Sistema de Soporte de Decisiones VRP

Download all Manual in Spanish

URL LINKS

OPTEX Mathematical Modeling System

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SUPPORT MANUALS (ENGLISH)
OPTEX General Description
OPTEX Installation
OPTEX Tutorial Implementation VRP Model

Download all Manual in English

URL LINKS

OPTΣX Mathematical Modeling System

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TUTORIAL PRESENTATIONS
SESSION 1: Introduction
SESSION 2: VRP Modeling in EXCEL
SESSION 3: Using EXCEL to Load Data
SESSION 4: OPTEX-GUI – Loading Models
SESSION 5: Loading and Checking Industrial Data
SESSION 6: Solving Mathematical Models
SESSION 7: SQL Servers
SESSION 8: Optimization Technologies

Download all Tutorials

MATHEMATICAL MODELING PROCESS

REAL WORLD

MATHEMATICAL MODELING PROCESS

REAL WORLD

ALGEBRAIC MODEL

$$Min \quad \Psi = \sum_{t=1}^{T} \sum_{i=1}^{N_T} \psi_{(i,t)}$$

s.a.

$$\psi_{(i,t)} = \frac{c_{(i,t)}}{2} \cdot P_{(i,t)}^{\ 2} + e_{(i,t)} \cdot P_{(i,t)}$$

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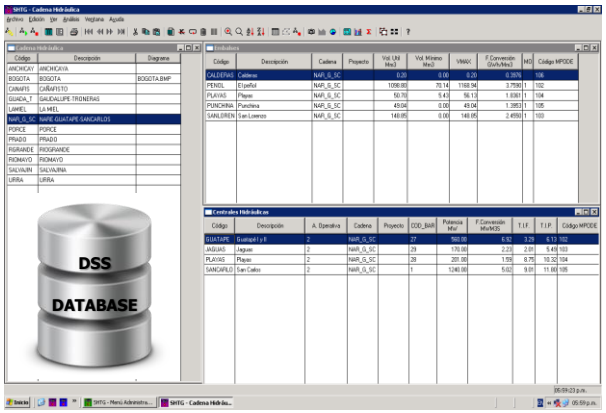
DATA MODEL



MODELERS

DECISION MAKERS

Analytics

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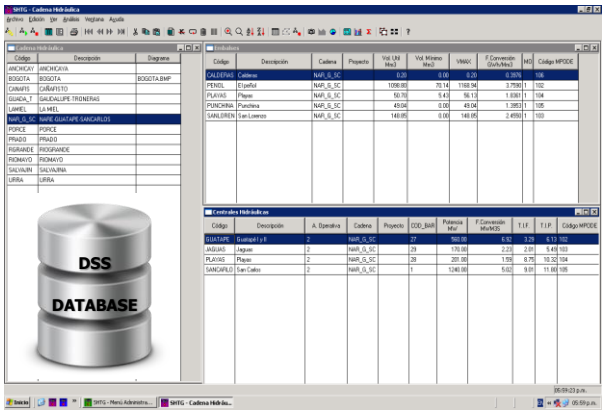
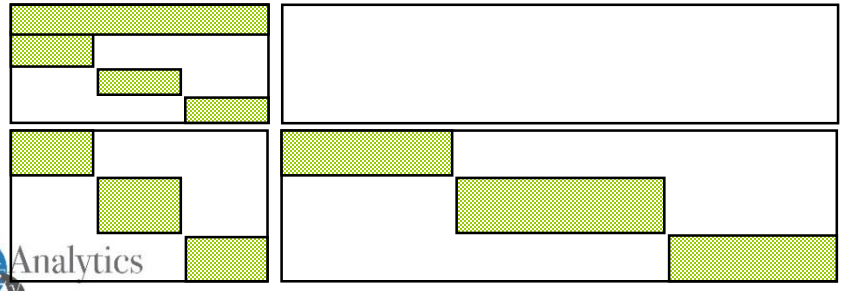


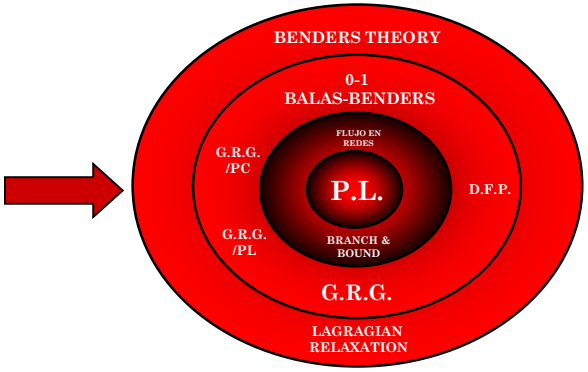
MODELERS

DECISION MAKERS

MATRIX GENERATION



NUMERICAL MODEL



OPTIMIZATION SOLVER

x, π

MATHEMATICAL MODELING PROCESS

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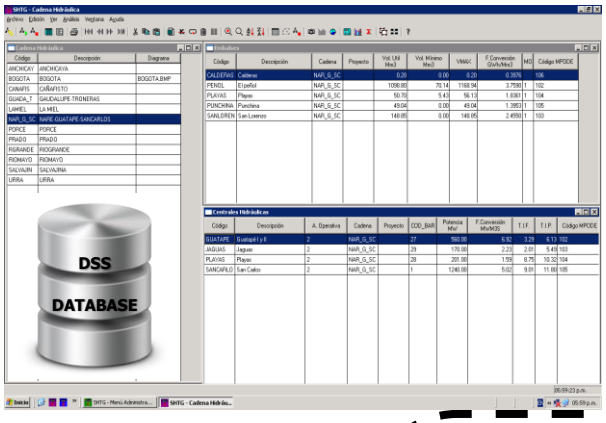
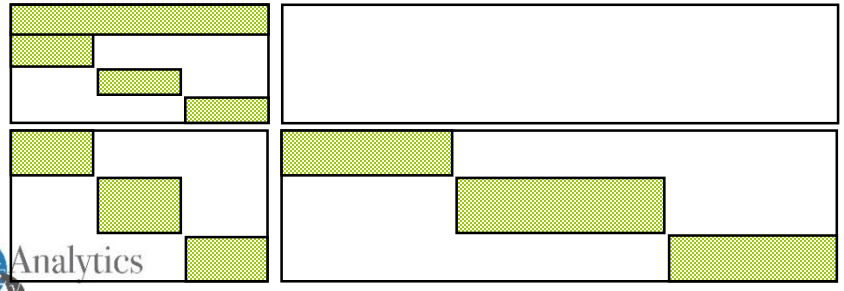


MODELERS

DECISION MAKERS

MUST BE THIRD PART PROVIDER

MATRIX GENERATION



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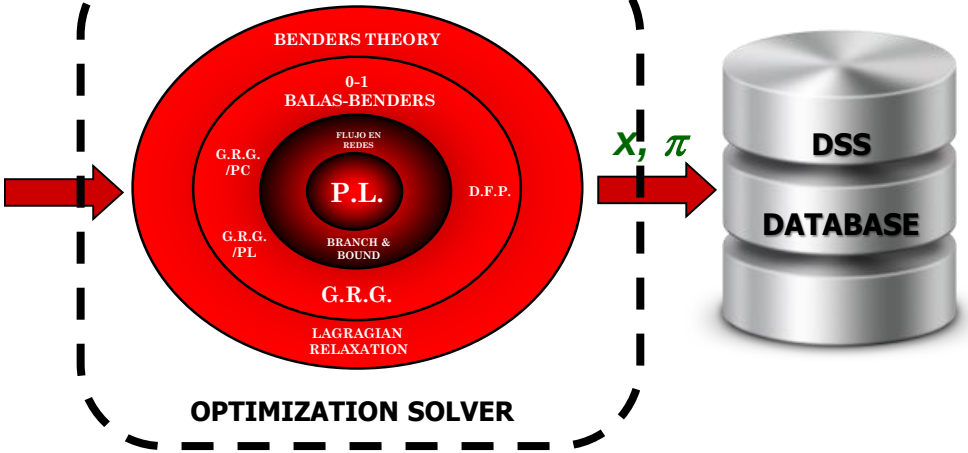

Analytics

OPTEX Mathematical Modeling System

MATHEMATICAL MODELING PROCESS

REAL WORLD

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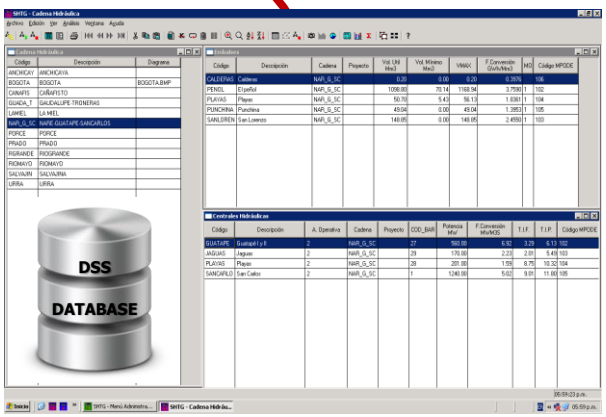
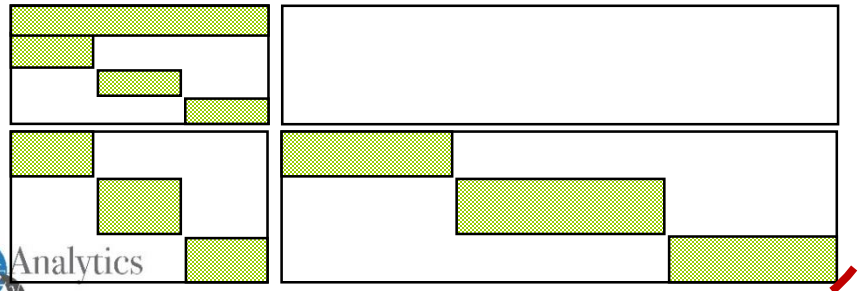


MODELERS

DECISION MAKERS

MATRIX GENERATION



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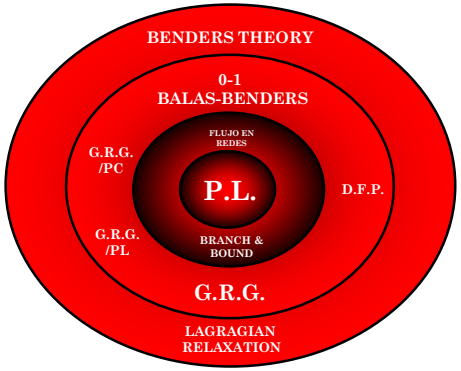

OPTIMIZATION SOLVER

X, π

Analytics

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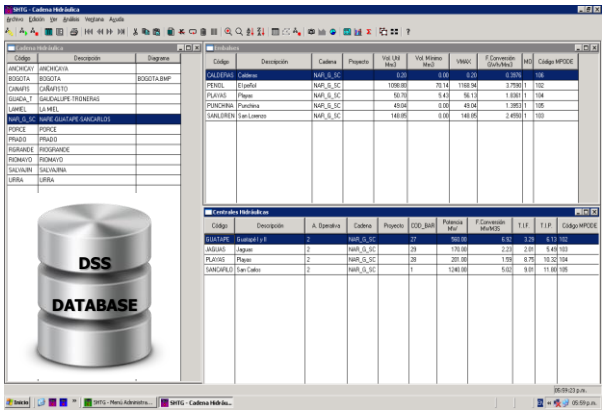

MODELERS

INFORMATION SYSTEMS

Analytics

MATHEMATICAL MODELING PROCESS

REAL WORLD

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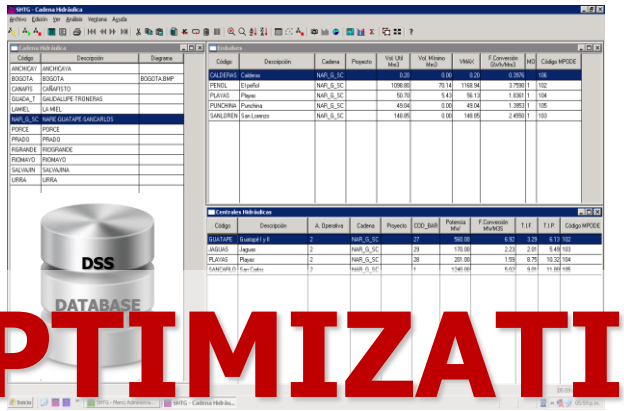
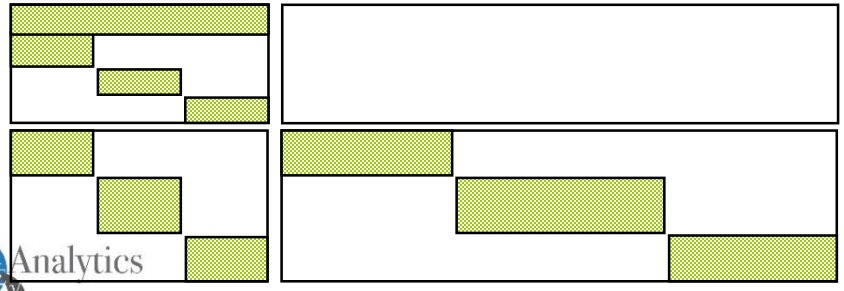


OPTIMIZATION TECHNOLOGIES

MATRIX GENERATION



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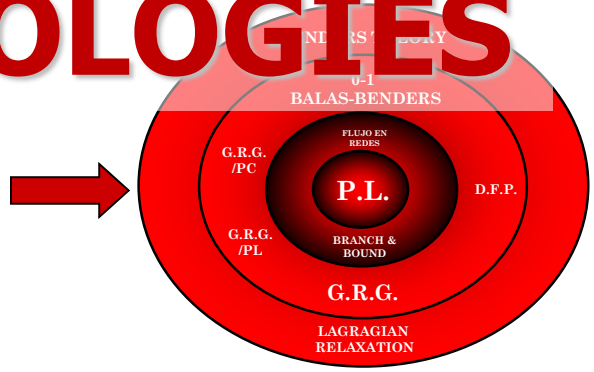


OPTIMIZATION SOLVER

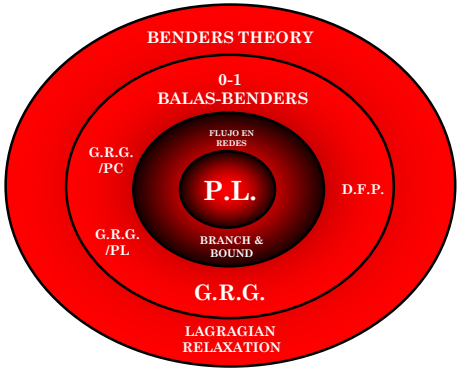
MATHEMATICAL MODELING PROCESS

VISUALIZATION & CONTROL TECHNOLOGIES

REAL WORLD

MODELERS

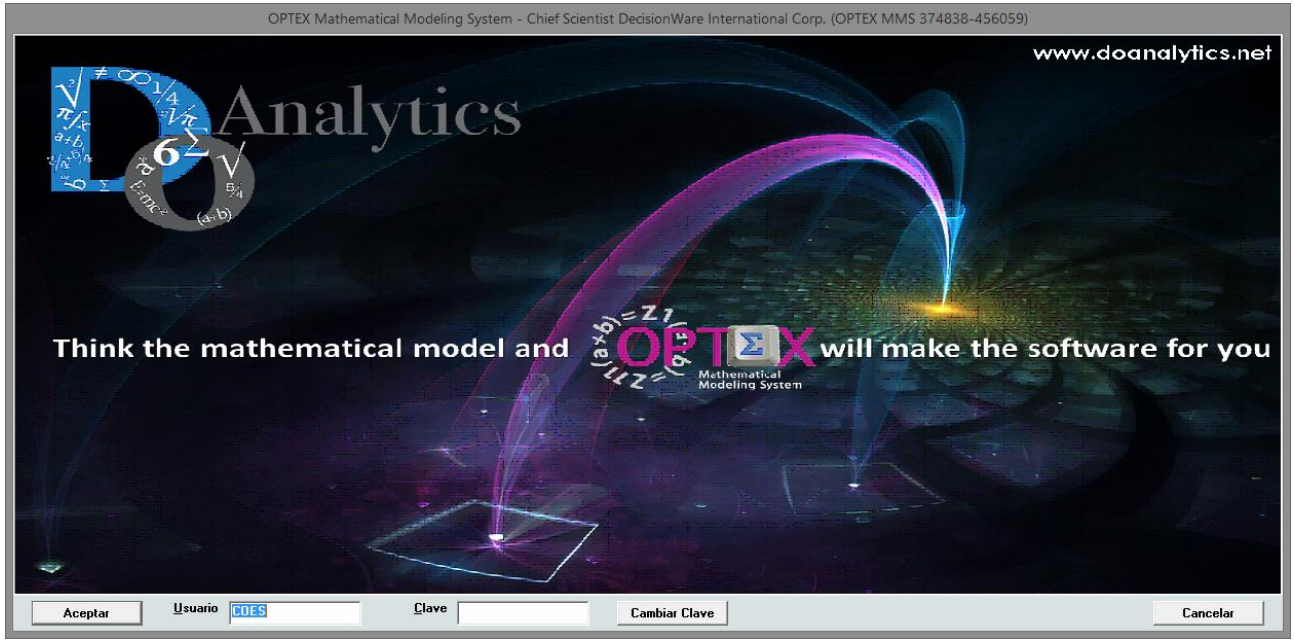
DECISION MAKERS



OPTIMIZATION SOLVER

x, π

Analytics



What is new with OPTEX ?

TRADITIONAL WAY

TRADITIONAL WAY

OPTΣX WAY

Mathematical Modeling System

THE BEST WAY TO MAKE OPTIMIZATION SOFTWARE IS NOT HAVING TO DO IT

REAL WORLD

DECISION MAKERS

MODELERS

DEVELOPING MATHEMATICAL MODELS

ALGEBRAIC MODEL

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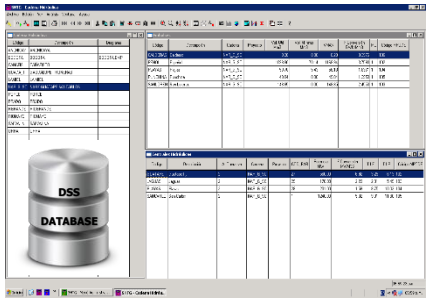
OPTEX
Mathematical Modeling System

REAL WORLD

DECISION MAKERS

MODELERS

DATA MODEL



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PROGRAMMERS

DEVELOPING MATHEMATICAL MODELS

TRADITIONAL WAY

OPTIMIZATION TECHNOLOGY

Dev C++ | GAMS | ILOG An IBM Company OPL | FICO Mosel | AIMMS | AMPL STREAMLINED MODELING FOR REAL OPTIMIZATION

PROGRAMMING

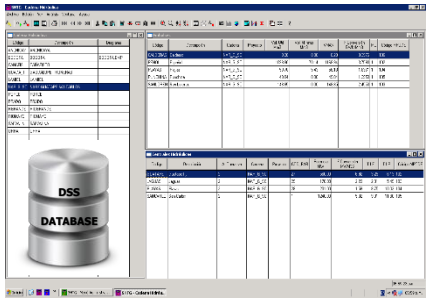
Analytics

OPTEX Mathematical Modeling System

REAL WORLD

DECISION MAKERS

DATA MODEL



OPTEX WAY

DEVELOPING MATHEMATICAL MODELS

MODELERS

FILLING THE BLANKS

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CODE GENERATION

OPTIMIZATION TECHNOLOGY

Dev C++ · GAMS · ILOG An IBM Company OPL · FICO Mosel · AIMMS · AMPL STREAMLINED MODELING FOR REAL OPTIMIZATION

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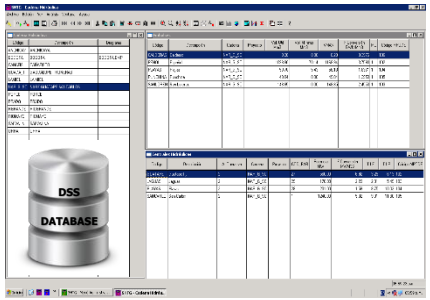
OPTEX Mathematical Modeling System

REAL WORLD

DECISION MAKERS

DATA MODEL



OPTEX WAY

DEVELOPING MATHEMATICAL MODELS

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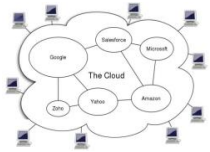
CODE GENERATION

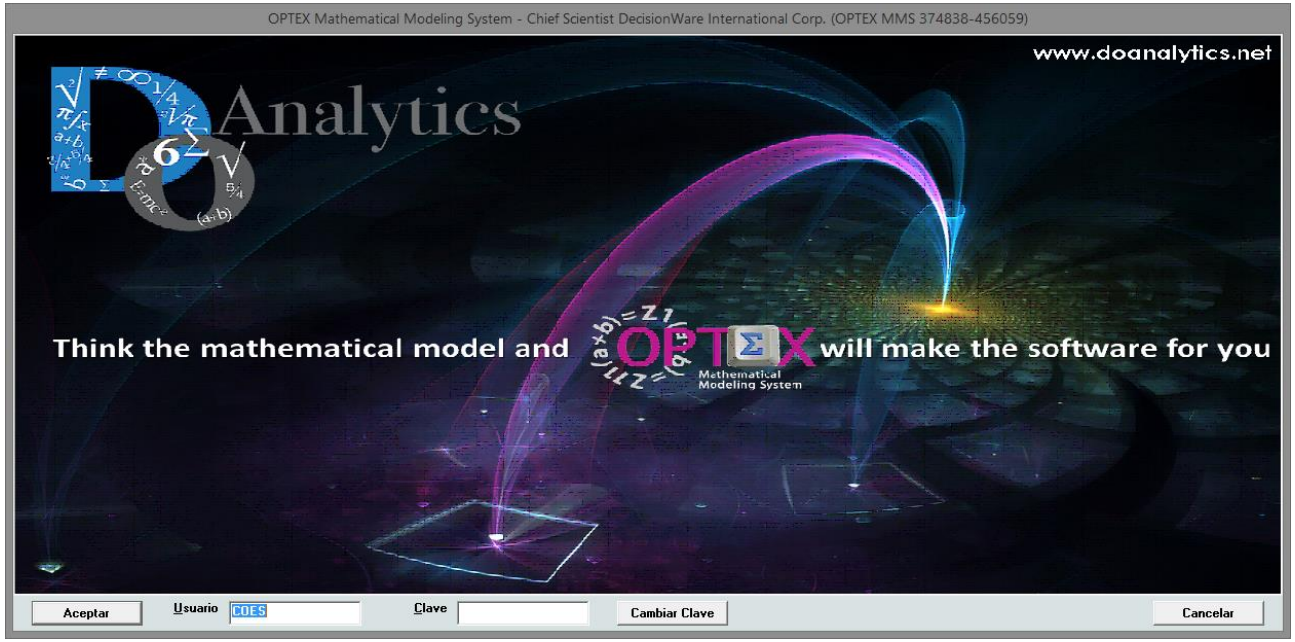
OPTIMIZATION TECHNOLOGY

OPL



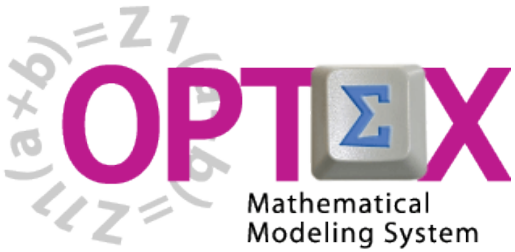
CLOUD

Analytics



OPTEX is the result of more than twenty years of experience in multiple optimization projects applied to real life problems, developed in several countries, economical sectors and cultures;

Now DOA share the benefits of OPTEX with the Mathematical Programming Community.


OPTΣX
Mathematical
Modeling System

MATHEMATICAL MODELERS

ODBC

DB2
ORACLE
EXCEL
DBF
SQE SERVER
MySQL

ERP

USER ORIENTED SYSTEMS

IMPRESS

OPTΣX Mathematical Modeling System

SYSTEM FOR DSS SYSTEMS

FICO

AIMMS

ILOG An IBM Company

ODME

ALGEBRAIC LANGUAGE

DEV C++

The Cloud

CLOUD

GAMS

ILOG An IBM Company

OPL

FICO Mosel

AIMMS

AMPL STREAMLINED MODELING FOR REAL OPTIMIZATION

OPTIMIZATION LIBRARY

COIN-OR COMPUTATIONAL INFRASTRUCTURE FOR OPERATIONS RESEARCH

LPS

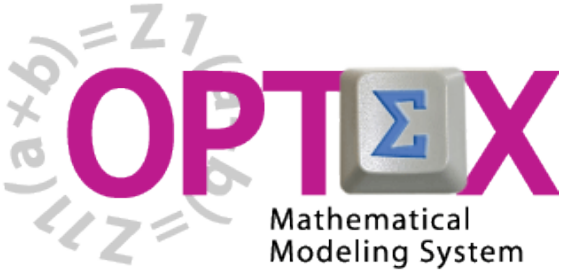
FICO Xpress

GUROBI OPTIMIZATION

ILOG An IBM Company

CPLEX

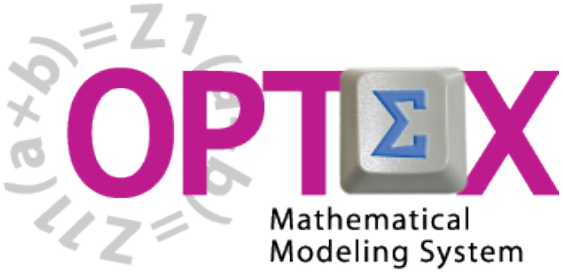
Analytics



was developed to support real mathematical modeling projects since 1991, now OPTEX is a commercial optimization technology supported by DO ANALYTICS LLC.

OPTEX dramatically simplifies the developing and solving of complex optimization applications by supporting:

- **Rapid Prototyping**
- **Big Data Intensive Optimization**
- **Decision-Making under Uncertainty**
- **Integrate Multiples Languages and Optimization Technologies**
- **Optimization in the Cloud**
- **Advanced Optimization using EXCEL Tables**



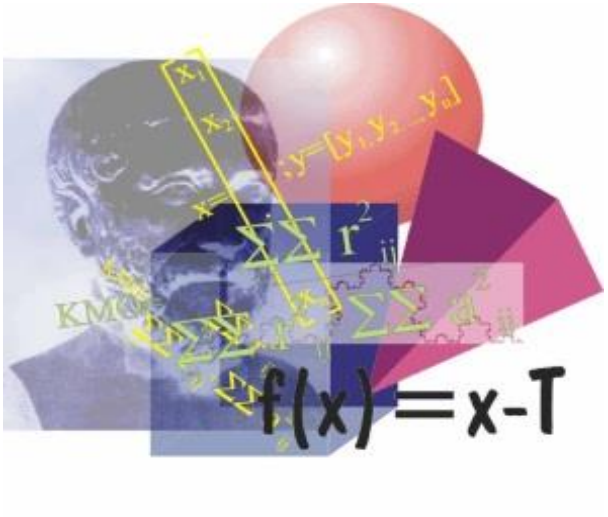
IS A META-FRAMEWORK (AN EXPERT SYSTEM, A ROBOT)

ORIENTED TOWARDS THE DESIGN, IMPLEMENTATION AND SETUP OF DECISION SUPPORT SYSTEMS BASED ON MATHEMATICAL PROGRAMMING WITH SPECIAL EMPHASIS IN THE DEVELOPMENT OF FINAL USER APPS:

- **ALGEBRAIC FORMULATION IS INDEPENDENT FROM ANY COMPUTER PROGRAMMING LANGUAGE**
- **CAN BE CONNECTED WITH ANY DATA SERVER**
- **CAN BE CONNECTED TO ANY VISUALIZATION SYSTEM**

THEREBY GENERATING APPS USING MULTIPLE COMMERCIAL OR NONCOMMERCIAL TECH ACCORDING TO THE CLIENTS' NEEDS

DATABASE ALGEBRAIC LANGUAGE
(THE NEW PARADIGM)



CLICK OVER THE IMAGE TO OBTAIN MORE INFORMATION

OPTEX sees the implementation of a Decision Support System as a load of a Relational Information System converting the mathematical modeling and the software production in a "filling the blanks" process. The lan-wan environment makes easy the simultaneous work, of several modelers, using the power of internet and the database servers.

MATHEMATICAL MODELS INFORMATION SYSTEM (MMIS)

An information system allows you to manage the data of a set of entities (objects).

An information system of a mathematical model required to define the entities that are part of the algebraic formulation of mathematical problems, these entities are associated with indexes (or sub-indices) which identifies the objects included in the mathematical model.

OPTEX assumes that the structure of the information system (data model) follows the principles of the relational information systems (database) which are supported in the so-called relational algebra.

SUGGESTION:
If the reader is not familiar with relational databases, we suggest that read about technical literature and OPTEX technical manuals related to the topic, since these information guidelines will help you to manage information systems which access the computer programs to solve mathematical problems:

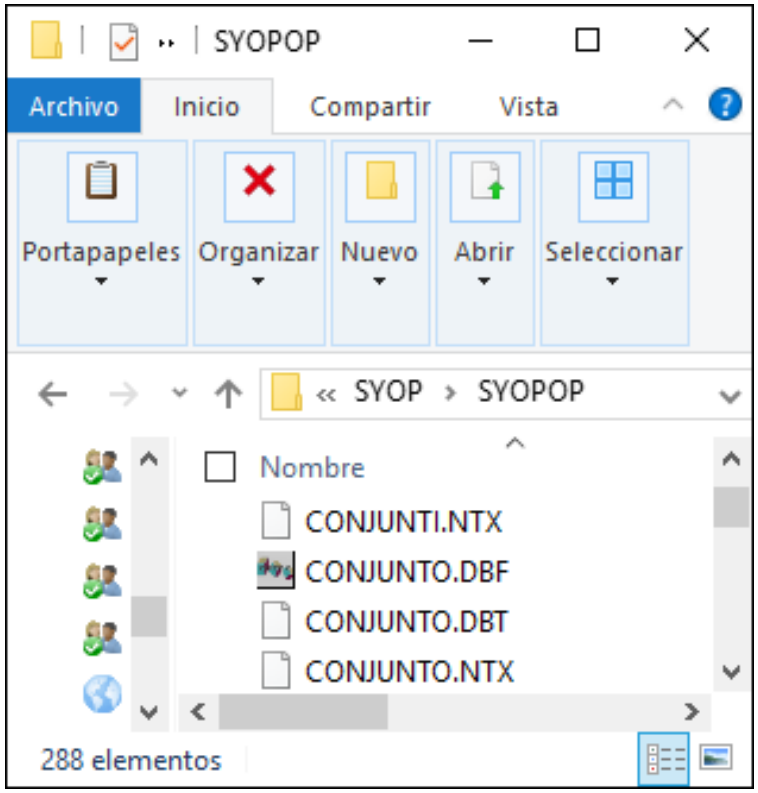
- http://www.doanalytics.net/Documents/Modelo_Relacional.pdf
- http://www.doanalytics.net/Documents/Manual-OPTEX-Modelamiento-Sistema-Informacion-IDIS.pdf
- http://www.doanalytics.net/Documents/Manual-OPTEX-Administrador-Validacion-Datos.pdf

MANAGEMENT OF DBASE (DBF) FILES

OPTEX always uses tables in DBF format. This is because that the areas of control of OPTEX (MMIS) tables are always handled in DBF. In the case of the areas of application data (IDIS), they can be handled DBF tables or servers type SQL acceded using ODBCs. It is required to take into account two important aspects in the management of the DBF tables:

- **DBT Memo Files: When tables contain MEMO fields, the managers of DBF databases linked a special table to store the MEMOs called XXXXX.DBT, where XXXXX is the name of the table containing fields MEMOs. It is important that these two tables (the DBF and the DBT) must be handled jointly; when the DBT table is lost, for any reason, it is possible to lose data stored in DBF table.**

- **NTX Index Files: to control the order of access of records in a table, and to facilitate relationships between tables that are linked through common fields, OPTEX MMS uses the NTX index files. There may be multiple files NTX, one for each order (index) that you want to have, for a DBF table. The following image presents the case of the table CONJUNTO.DBF, you have MEMOs stored in the file CONJUNTO.DBT and whose ordering is set from two points of view: CONJUNTO.NTX and CONJUNT1.NTX.**



DATA ORGANIZATION

This topic is important for users to directly use OPTEX installed on their computer.

Prior to the loading of the MMIS and, should be into account the way in which information for the integrated management of all mathematical modeling system should be organized. Under the conception of OPTEX, an information system is composed of multiple databases (group of tables) that are conceived as an information areas and are classified into:

- **Control of Information Systems: stores the tables corresponding to a data model of an information system. It is implemented in DBASE tables and it is part of the MMIS.**
- **Control of Mathematical Models: stores the tables corresponding to the formulation of optimization mathematical models. It is implemented in DBASE tables and it is part of the MMIS**
- **Business/Industrial Data: stores the tables corresponding to the data to which the user of the application has access. This area comprises two areas of data: the permanent data of the application, and the data of scenarios of the mathematical models. The user chooses the type of database that wants to handle, may be in DBASE tables or tables in a server type SQL. It corresponds to the so-called IDIS**

DATA ORGANIZATION

OPTEX, considers the following areas or data directories:

- **OPTEX-GUI Control Area: stores the tables of OPTEX-GUI control. It is designed and controlled by DOA;**
- **OPTEX-MMIS Control Area: stores the MMIS control tables. It is designed and controlled by DOA;**
- **IDIS Control Area: stores the IDIS control tables. This area controls all the areas in which subdivides the IDIS. It is configured by the OPTEX-GUI administrator;**
- **Mathematical Models (MMIS) Data Area: stores data that define mathematical optimization models. It must be configured by the administrator/modeler of OPTEX-MMIS;**
- **IDIS Data Area: stores permanent IDIS data, it must be maintained by the IDIS users and is controlled by IDIS Control Area;**
- **Scenarios Family Data Area: stores data that are common to a family of scenarios, it must be maintained by the IDIS users and is controlled by the IDIS Control Area. Data from the family of scenarios is located from the area (root) scenarios (which is defined in the table of parameterization of applications as described in the Manual OPTEX-GUI Administrator). An area corresponds to each scenario family.**
- **Scenarios Data Area: stores data specific to a scenario, it must be maintained by IDIS users, receives data from the solution of models, and is controlled by the IDIS Control Area. In this area OPTEX stored data related to the algebraic and matrix/vectors structures of mathematical models and several reports. Scenarios data area is located under the directory associated with the family of scenarios. Each scenario has an area.**

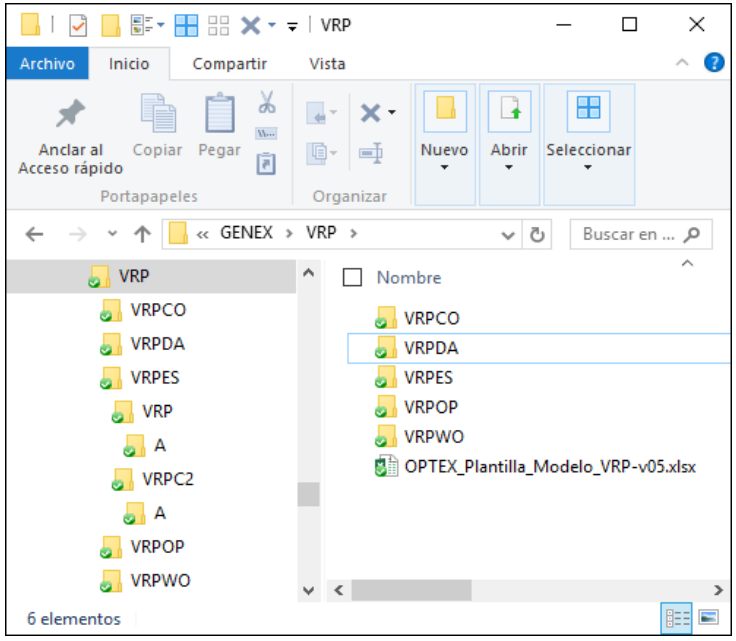
DATA ORGANIZATION

AREAS OF INFORMATION SYSTEM		
AREA	**DBF TABLES DIRECTORY**	**SQL TABLES PREFIX**
Control OPTEX-GUI	C:/**OPTEX**/**OPTEX**	(0)
Control OPTEX-MMIS	C:/**OPTEX**/**OPTEX**	(0)
Control IDIS DATA MODEL	C:/**OPTEX**/aaa/aaa**CO** (1)	(0)
Control Mathematical Models (MMIS)	C:/**OPTEX**/aaa/aaa**OP** (1)	(0)
IDIS	C:/**OPTEX**/aaa/aaa**DA** (1)	(2)
ROOT OF THE FAMILY OF SCENARIOS	C:/**OPTEX**/aaa/aaa**ES**/fff (1)	fff_ (1)
ESCENARIOS DE LA FAMILIA	C:/**OPTEX**/aaa/aaa**ES**/fff/eee (1)	fff_eee_ (1)

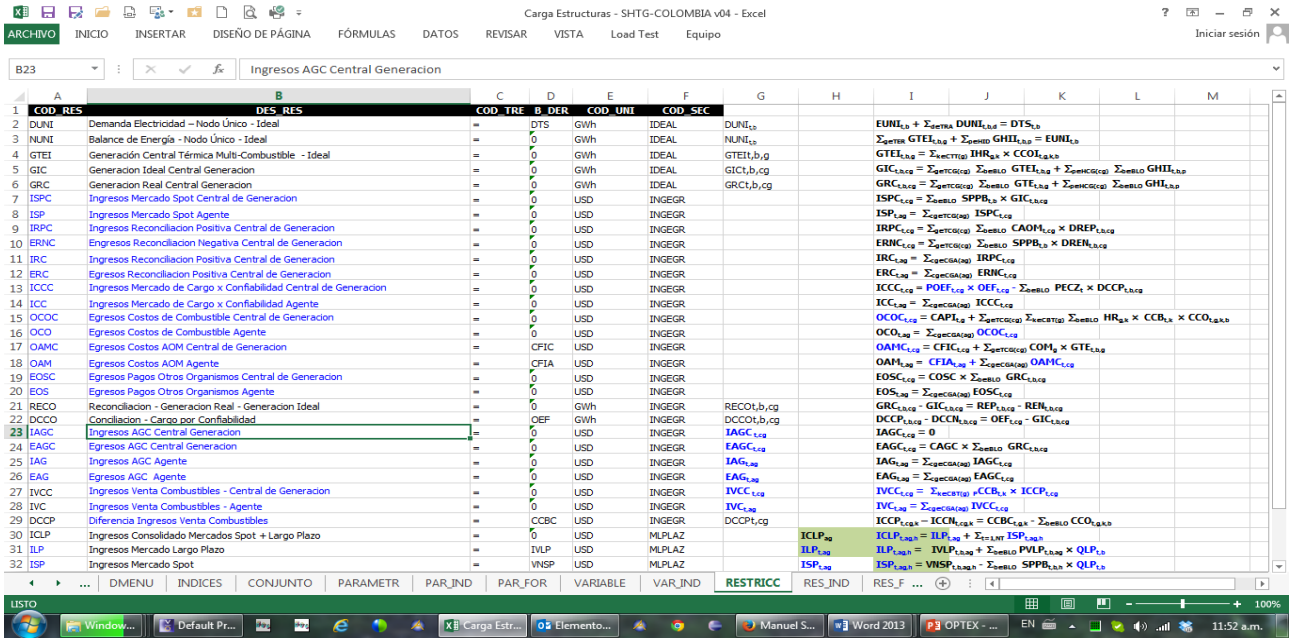
Nota**:**
(0) DBF tables
(1) aaa is associated with the application, **fff** with the family of scenarios and **eee** with the scenario
(2) SQL tables without prefix

The image shows the directories associated with the data areas of the OPTEX application.

Clarifies that directories can be arranged in any way, the choice in this case is to place them all in the same directory where the directory name (VRP) is a mnemonic that acts as a prefix in all directories.



OPTEX
Mathematical Modeling System

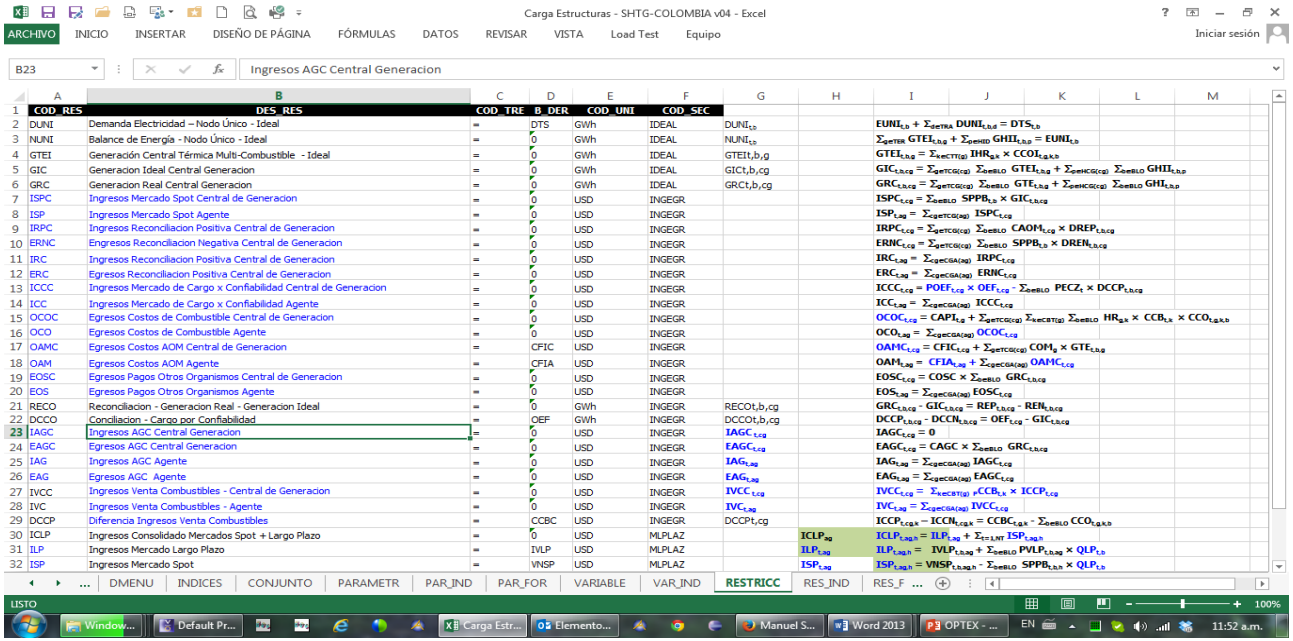


What is new with OPTEX-EXCEL-MMS ?

Analytics

OPTEX Mathematical Modeling System

OPTEX-EXCEL-MMS

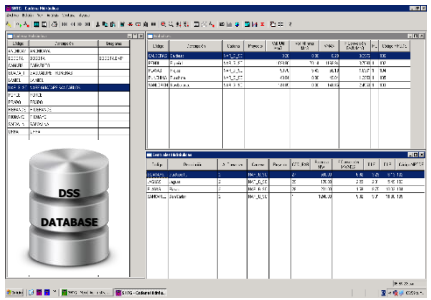


With OPTEX-EXCEL-MMS the mathematical modelers can formulate multi model decision support systems, with no knowledge about computer technologies, also can generate complex models in several algebraic computer languages linked to any data server that supports ODBCs connections.

Analytics

OPTEX Mathematical Modeling System

DATA MODEL



ALGEBRAIC MODEL

$$Min \quad \Psi = \sum_{t=1}^{T} \sum_{i=1}^{N_T} \Psi_{(i,t)}$$

s.a.

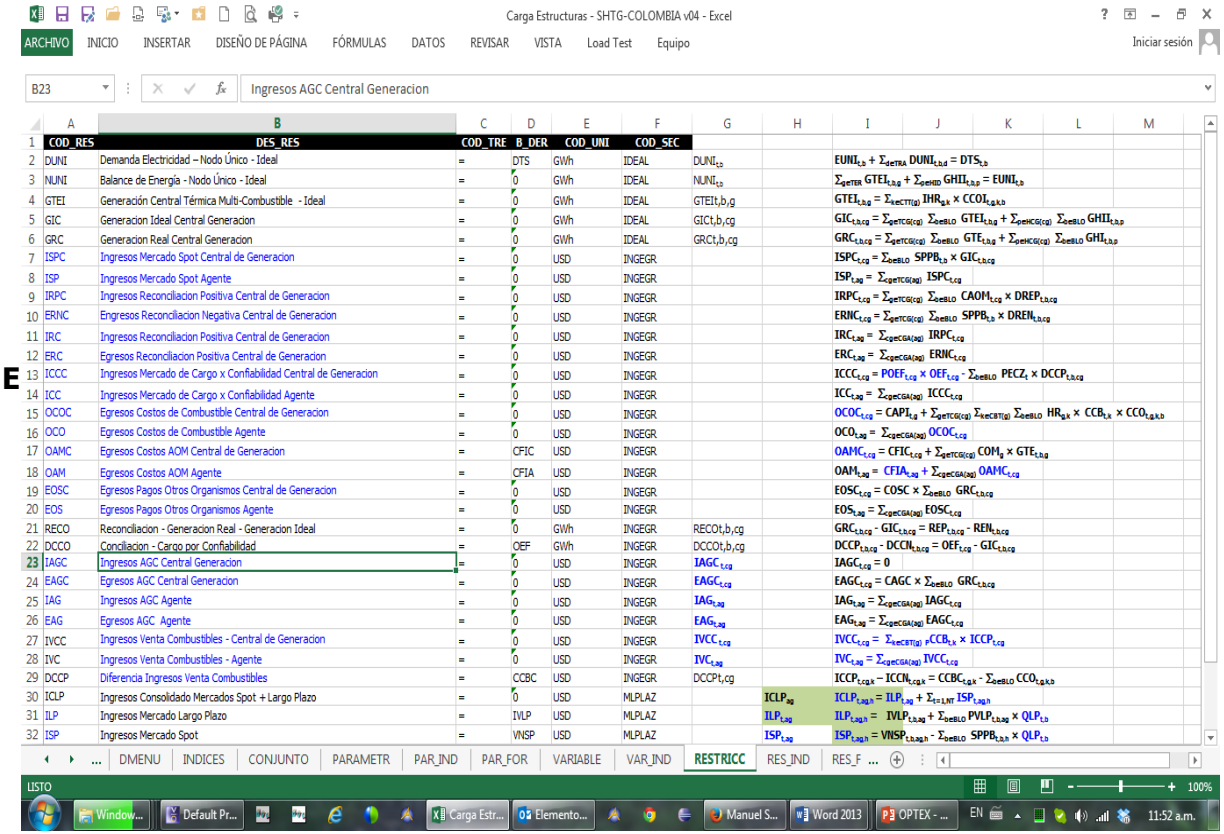
$$\Psi_{(i,t)} = \frac{c_{(i,t)}}{2} \cdot P_{(i,t)}^{\ 2} + e_{(i,t)} \cdot P_{(i,t)}$$

$$V_{(j,t+1)} = V_{(j,t)} + \tau \cdot \left(A_{(j,t)} - Q_{(j,t)} - S_{(j,t)} \right)$$

$$P_{(j,t)} = \rho_{(j)} \cdot Q_{(j,t)}$$

FILLING THE BLANKS

CLICK OVER THE IMAGE TO OBTAIN MORE INFORMATION



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	COD_RES	DES_RES	COD_TRE	B_DER	COD_UNI	COD_SEC							
2	DUNI	Demanda Electricidad – Nodo Único - Ideal	=	DTS	GWh	IDEAL	$DUNI_{t,b}$		$EUNI_{t,b} + \Sigma_{deTRA} DUNI_{t,bd} = DTS_{t,b}$				
3	NUNI	Balance de Energía - Nodo Único - Ideal	=	0	GWh	IDEAL	$NUNI_{t,b}$		$\Sigma_{geTER} GTEI_{t,b,g} + \Sigma_{geHID} GHII_{t,b,g} = EUNI_{t,b}$				
4	GTEI	Generación Central Térmica Multi-Combustible - Ideal	=	0	GWh	IDEAL	GTEIt,b,g		$GTEI_{t,b,g} = \Sigma_{keCTT(g)} IHR_{g,k} \times CCOI_{t,g,k,b}$				
5	GIC	Generacion Ideal Central Generacion	=	0	GWh	IDEAL	GICt,b,cg		$GIC_{t,b,cg} = \Sigma_{geTCG(cg)} \Sigma_{beBLO} GTEI_{t,b,g} + \Sigma_{geHCG(cg)} \Sigma_{beBLO} GHII_{t,b,p}$				
6	GRC	Generacion Real Central Generacion	=	0	GWh	IDEAL	GRCt,b,cg		$GRC_{t,b,cg} = \Sigma_{geTCG(cg)} \Sigma_{beBLO} GTE_{t,b,g} + \Sigma_{geHCG(cg)} \Sigma_{beBLO} GHI_{t,b,p}$				
7	ISPC	Ingresos Mercado Spot Central de Generacion	=	0	USD	INGEGR			$ISPC_{t,cg} = \Sigma_{beBLO} SPPB_{t,b} \times GIC_{t,b,cg}$				
8	ISP	Ingresos Mercado Spot Agente	=	0	USD	INGEGR			$ISP_{t,ag} = \Sigma_{cgeTCG(ag)} ISPC_{t,cg}$				
9	IRPC	Ingresos Reconciliacion Positiva Central de Generacion	=	0	USD	INGEGR			$IRPC_{t,cg} = \Sigma_{geTCG(cg)} \Sigma_{beBLO} CAOM_{t,cg} \times DREP_{t,b,cg}$				
10	ERNC	Engresos Reconciliacion Negativa Central de Generacion	=	0	USD	INGEGR			$ERNC_{t,cg} = \Sigma_{geTCG(cg)} \Sigma_{beBLO} SPPB_{t,b} \times DREN_{t,b,cg}$				
11	IRC	Ingresos Reconciliacion Positiva Central de Generacion	=	0	USD	INGEGR			$IRC_{t,ag} = \Sigma_{cgeCGA(ag)} IRPC_{t,cg}$				
12	ERC	Egresos Reconciliacion Positiva Central de Generacion	=	0	USD	INGEGR			$ERC_{t,ag} = \Sigma_{cgeCGA(ag)} ERNC_{t,cg}$				
13	ICCC	Ingresos Mercado de Cargo x Confiabilidad Central de Generacion	=	0	USD	INGEGR			$ICCC_{t,cg} = POEF_{t,cg} \times OEF_{t,cg} - \Sigma_{beBLO} PECZ_t \times DCCP_{t,b,cg}$				
14	ICC	Ingresos Mercado de Cargo x Confiabilidad Agente	=	0	USD	INGEGR			$ICC_{t,ag} = \Sigma_{cgeCGA(ag)} ICCC_{t,cg}$				
15	OCOC	Egresos Costos de Combustible Central de Generacion	=	0	USD	INGEGR			$OCOC_{t,cg} = CAPI_{t,g} + \Sigma_{geTCG(cg)} \Sigma_{keCBT(g)} \Sigma_{beBLO} HR_{g,k} \times CCB_{t,k} \times CCO_{t,g,k,b}$				
16	OCO	Egresos Costos de Combustible Agente	=	0	USD	INGEGR			$OCO_{t,ag} = \Sigma_{cgeCGA(ag)} OCOC_{t,cg}$				
17	OAMC	Egresos Costos AOM Central de Generacion	=	CFIC	USD	INGEGR			$OAMC_{t,cg} = CFIC_{t,cg} + \Sigma_{geTCG(cg)} COM_g \times GTE_{t,b,g}$				
18	OAM	Egresos Costos AOM Agente	=	CFIA	USD	INGEGR			$OAM_{t,ag} = CFIA_{t,ag} + \Sigma_{cgeCGA(ag)} OAMC_{t,cg}$				
19	EOSC	Egresos Pagos Otros Organismos Central de Generacion	=	0	USD	INGEGR			$EOSC_{t,cg} = COSC \times \Sigma_{beBLO} GRC_{t,b,cg}$				
20	EOS	Egresos Pagos Otros Organismos Agente	=	0	USD	INGEGR			$EOS_{t,ag} = \Sigma_{cgeCGA(ag)} EOSC_{t,cg}$				
21	RECO	Reconciliacion - Generacion Real - Generacion Ideal	=	0	GWh	INGEGR	RECOt,b,cg		$GRC_{t,b,cg} - GIC_{t,b,cg} = REP_{t,b,cg} - REN_{t,b,cg}$				
22	DCCO	Conciliacion - Cargo por Confiabilidad	=	QEF	GWh	INGEGR	DCCOt,b,cg		$DCCP_{t,b,cg} - DCCN_{t,b,cg} = OEF_{t,cg} - GIC_{t,b,cg}$				
23	IAGC	Ingresos AGC Central Generacion	=	0	USD	INGEGR	$IAGC_{t,cg}$		$IAGC_{t,cg} = 0$				
24	EAGC	Egresos AGC Central Generacion	=	0	USD	INGEGR	$EAGC_{t,cg}$		$EAGC_{t,cg} = CAGC \times \Sigma_{beBLO} GRC_{t,b,cg}$				
25	IAG	Ingresos AGC Agente	=	0	USD	INGEGR	$IAG_{t,ag}$		$IAG_{t,ag} = \Sigma_{cgeCGA(ag)} IAGC_{t,cg}$				
26	EAG	Egresos AGC Agente	=	0	USD	INGEGR	$EAG_{t,ag}$		$EAG_{t,ag} = \Sigma_{cgeCGA(ag)} EAGC_{t,cg}$				
27	IVCC	Ingresos Venta Combustibles - Central de Generacion	=	0	USD	INGEGR	$IVCC_{t,cg}$		$IVCC_{t,cg} = \Sigma_{keCBT(g)} rCCB_{t,k} \times ICCP_{t,cg}$				
28	IVC	Ingresos Venta Combustibles - Agente	=	0	USD	INGEGR	$IVC_{t,ag}$		$IVC_{t,ag} = \Sigma_{cgeCGA(ag)} IVCC_{t,cg}$				
29	DCCP	Diferencia Ingresos Venta Combustibles	=	CCBC	USD	INGEGR	DCCPt,cg		$ICCP_{t,cg,k} - ICCN_{t,cg,k} = CCBC_{t,cg,k} - \Sigma_{beBLO} CCO_{t,g,k,b}$				
30	ICLP	Ingresos Consolidado Mercados Spot + Largo Plazo	=	0	USD	MLPLAZ		$ICLP_{ag}$	$ICLP_{t,ag,h} = ILP_{t,ag} + \Sigma_{t=1,NT} ISP_{t,ag,h}$				
31	ILP	Ingresos Mercado Largo Plazo	=	IVLP	USD	MLPLAZ		$ILP_{t,ag}$	$ILP_{t,ag,h} = IVLP_{t,b,ag} + \Sigma_{beBLO} PVLP_{t,b,ag} \times QLP_{t,b}$				
32	ISP	Ingresos Mercado Spot	=	VNSP	USD	MLPLAZ		$ISP_{t,ag}$	$ISP_{t,ag,h} = VNSP_{t,b,g,h} - \Sigma_{beBLO} SPPB_{t,b,h} \times QLP_{t,b}$				

MODEL IN EXCEL

.CSV FILES

CODE GENERATION

OPTIMIZATION TECHNOLOGY

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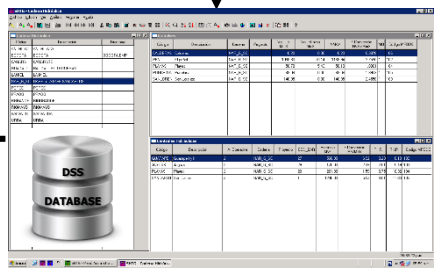
OPTEX Mathematical Modeling System

OPTEX Mathematical Modeling System

DATA MODEL



ALGEBRAIC MODEL

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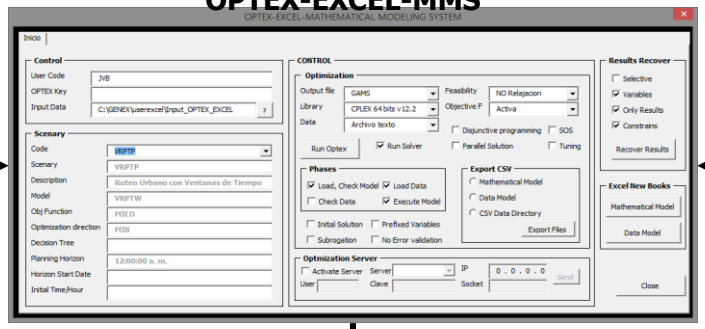
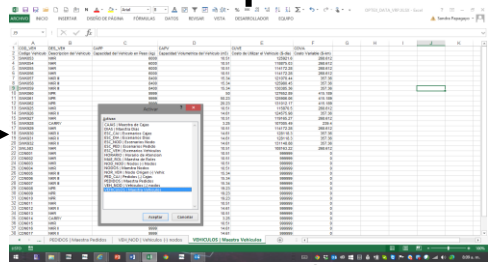
OPTEX-EXCEL-MMS

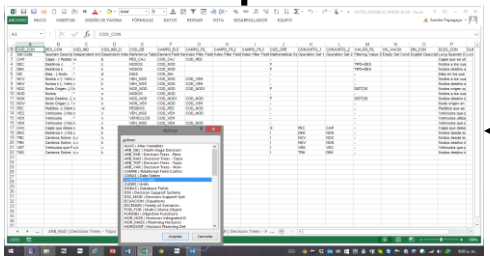


FILLING THE BLANKS

*.CSV FILES



DATA IN EXCEL

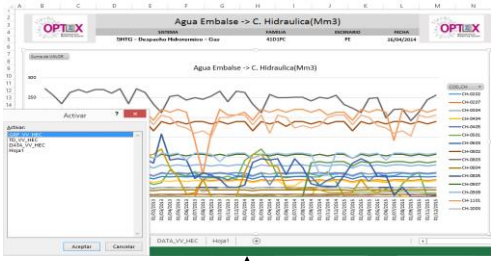


MODEL IN EXCEL

CODE GENERATION

OPTEX Mathematical Modeling System

OPTEX-EXCEL-GUI



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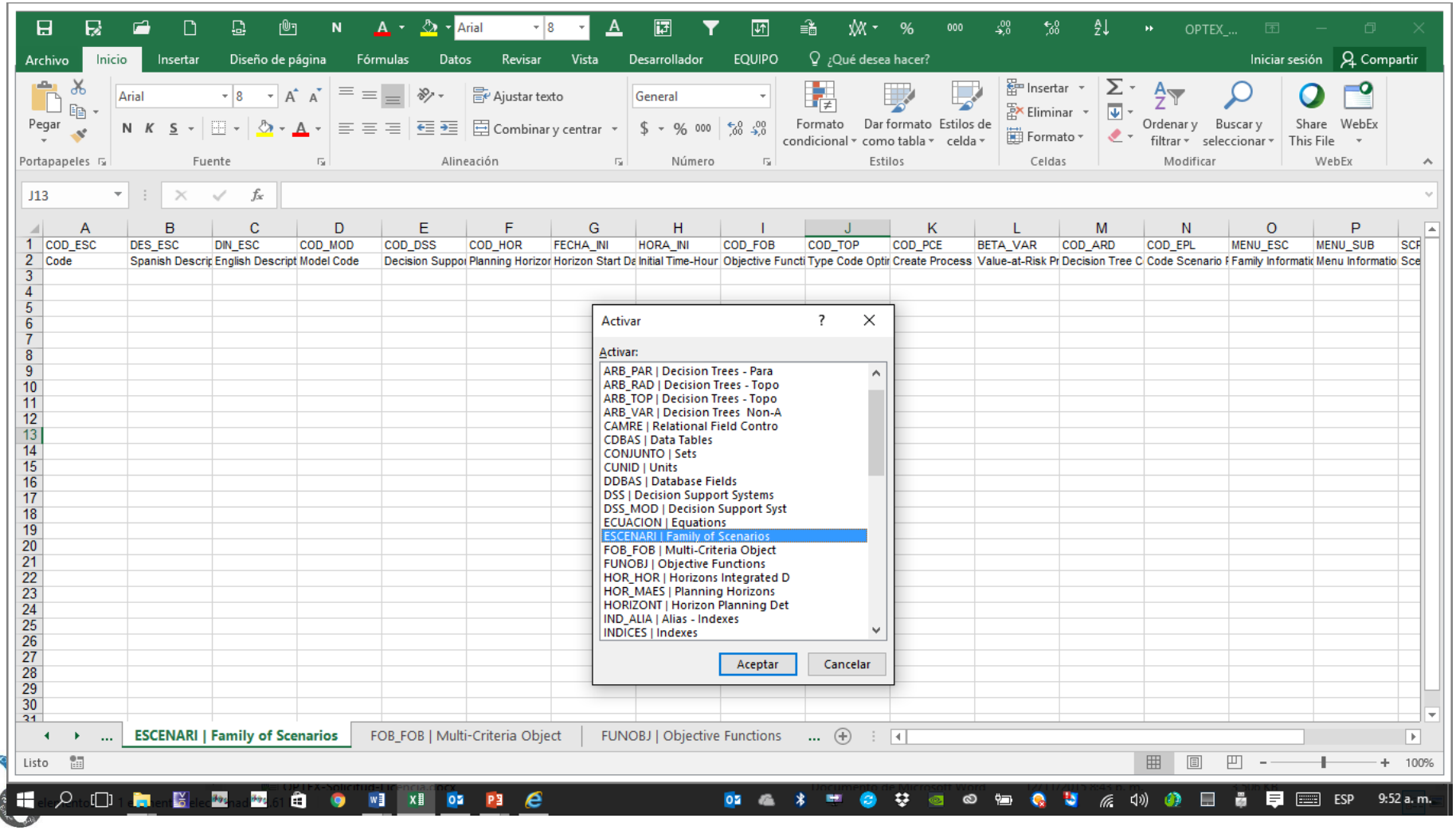
PRIMAL – DUAL VARIABLES

OPTEX-EXCEL-MMS TEMPLATE

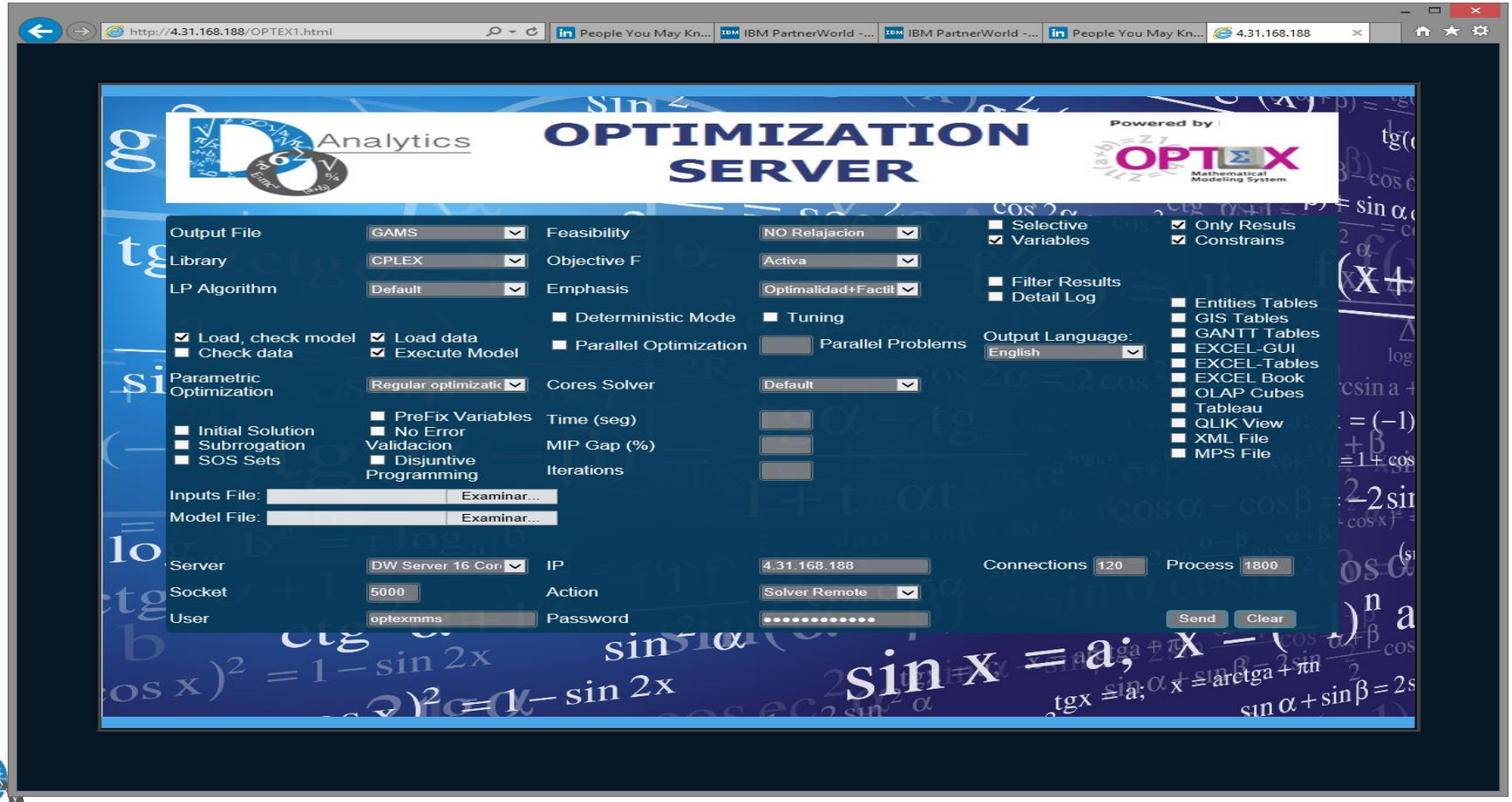
The EXCEL template is based on an EXCEL workbook comprising multiple sheets, one for each table that is required to load the elements of the mathematical model. Each sheet of the template is a two-dimensional table where the columns corresponding to the table fields and rows corresponding to data records; with the exception of the first and the second row, that containing the names and the brief description of the fields.



OPTEX WEB SERVICE

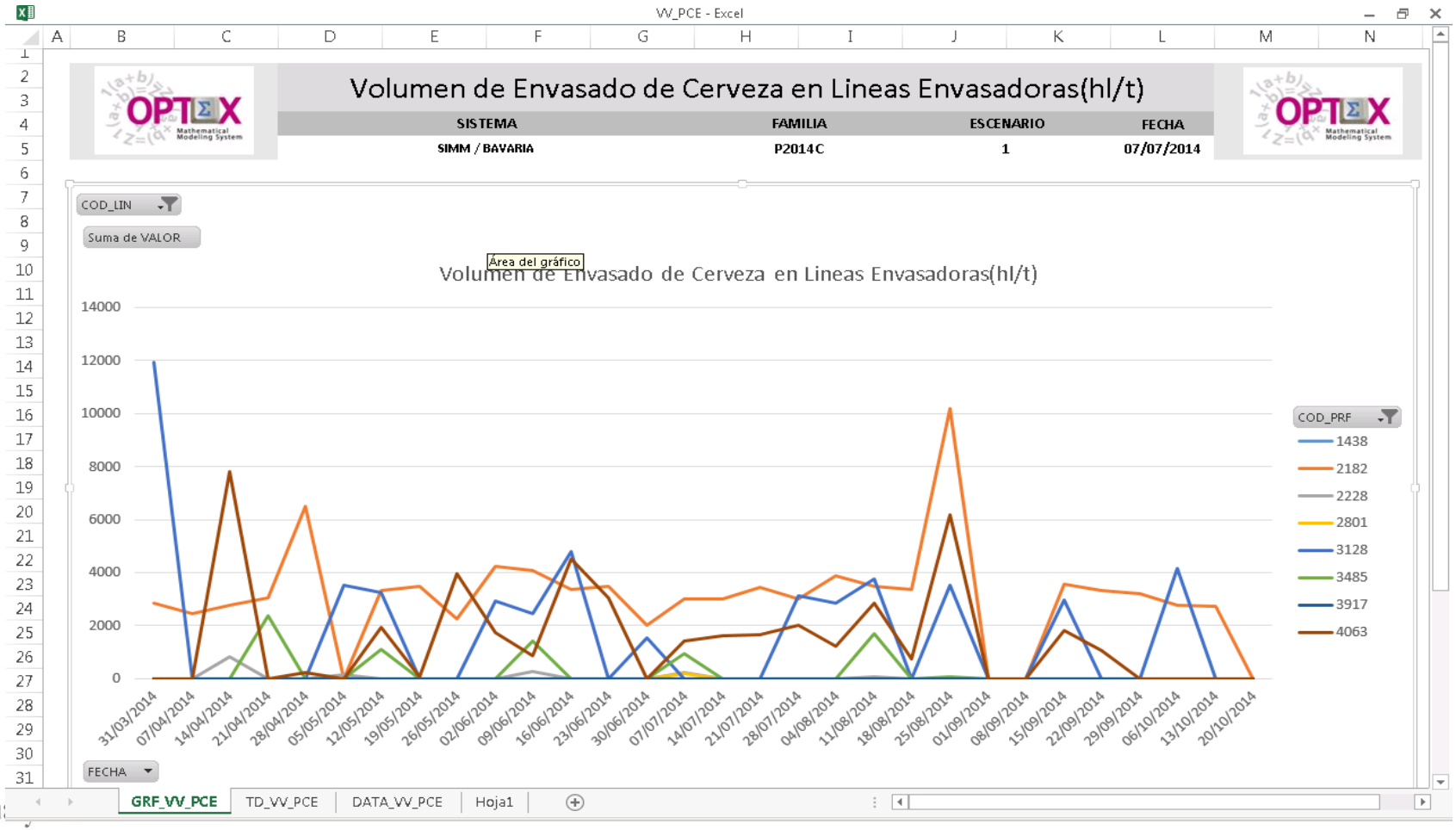
OPTEX-WEB is a web-oriented interface to access services provided by OPTEX, facilitating the OPTEX-EXEL-MMS user sending a request of process to solve a mathematical model in an OPTEX OPTIMIZATION SERVER.

To use this service, the user only requires having mathematical models on the OPTEX-EXCEL-MMS template and data in CSV files or an EXCEL template generated by OPTEX. It does not require installation of OPTEX.

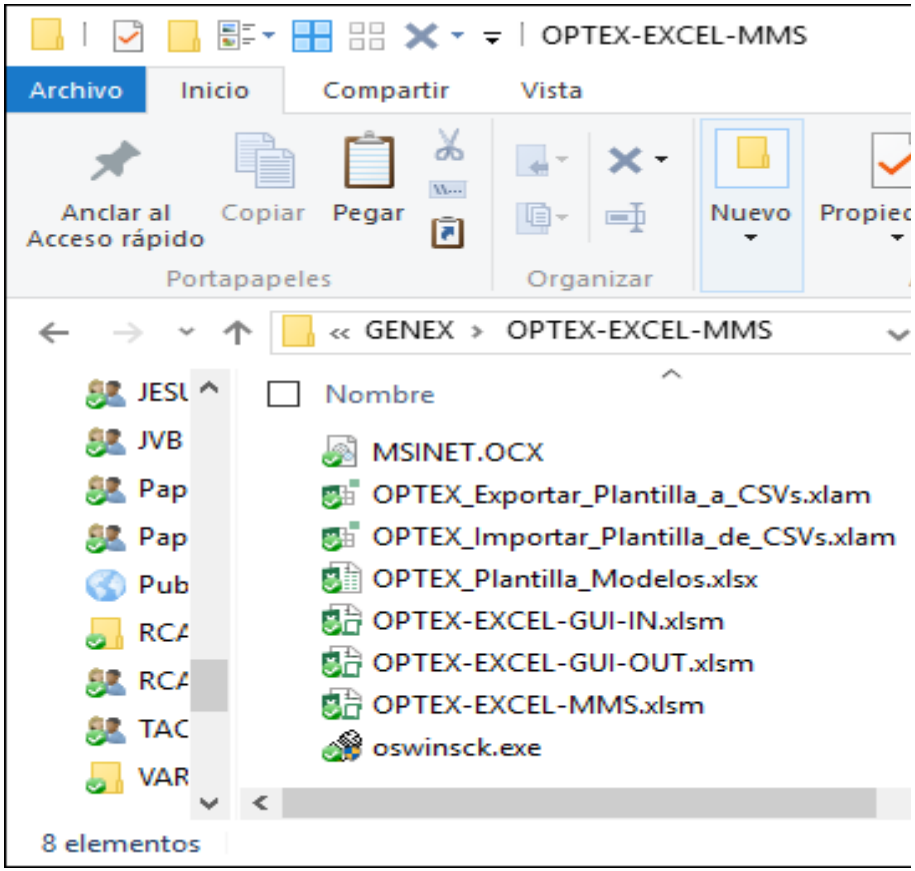


OPTEX-EXCEL-GUI

All the results of mathematical models can be visualized and analyzed using OPTEX-EXCEL-GUI, which corresponds to a graphical interface in EXCEL, based on dynamic graphs and dynamic tables. The interested reader can consult the OPTEX-EXCEL-GUI User Manual.



EXCEL COMPONENTS



To access **OPTEX-EXCEL Mathematical Modeling System** (**OPTEX-EXCEL-MMS**) the user only requires to get the components that are part of this product that are:
http://www.doanalytics.net/OPTEX/Download/OPTEX-EXCEL-MMS.ar

The services offered by **OPTEX-EXCEL-MMS** are:

- **EXCEL** add-ins to connect to **OPTEX**
- **OPTEX** template for implementation of mathematical models using **EXCEL**
- Conversion of **EXCEL** templates to **CSV** files (**C**omma **S**eparated **V**alues) and vice versa.
- Access to **OPTEX-OPTIMIZATION SERVER** located in a **DO ANALYTICS** cloud server, to solve mathematical problems
- Visualization of results using O**PTEX-EXCEL-GUI**.

Analytics

"the computer-based mathematical modeling is the greatest invention of all times"

Herbert Simon
First Winner of Nobel Prize in Economics (1978)

"for his pioneering research into the decision-making process within economic organizations"