EcosimPro
Modelling and Simulation Software

EDITORIAL

The EcosimPro team publishes newsletter number 3. A new number in this media of communication which addresses the latest activities and developments that have taken place, such as the new versions of PROOSIS 2.4 and EcosimPro 4.8 which have appeared on the market in the past few months.

An intense effort has also been made during this period to publicise this mathematical tool through acts such as the bestowal of an award for the best article on research in the field of Automatics using EcosimPro in 2010.

On the other hand, the book Introduction to Modelling and Simulation with EcosimPro has been written by our collaborators at Cordoba University under the leadership of Francisco Vazquez and published by Pearson. This book is free to all EcosimPro users and it can also be purchased in bookshops in hardcopy or electronic format. We hope it will be especially helpful for EcosimPro users who are starting out in this discipline.

In the past few months the EcosimPro team has been very active in different forums, presenting different papers on the use of EcosimPro in diverse fields: the ASME Turbo Expo 2010 Gas Turbine Technical Congress in Glasgow in June, the International Conference on Environmental Control and Life Support Systems organized by the ESA and NASA in Barcelona in July, and ITER project fusion process modelling in Madrid in September.

In this newsletter we continue to present some divulgative articles on the use of EcosimPro, and in this case two types of variables used in modelling are described. We hope it will help users to better understand the differences between diverse types of variables because it is one of the most frequent doubts. We want this section to include matters proposed by users and therefore encourage you to propose new topics.

Pedro Cobas Herrero
Head of the EcosimPro Development Team

INTERVIEW

Olga Asuar Alonso

Head of the Chemical Engineering section at Empresarios Agrupados

"Because of its great mathematical capacity, EcosimPro can simulate highly complex systems with a multitude of variables."

Olga Asuar graduated in Chemistry from the Universidad Autónoma de Madrid. She started her career at Empresarios Agrupados in 1983 as a nuclear power plant systems engineer. She

has been Head of the Chemical Engineering Section since 2001 and is in charge of decommissioning, waste management and desalination projects.

Interviewer: A math tool such as EcosimPro has a number of different applications, including use in process plants. What advantages does it offer for running a desalination plant? What has your personal experience been with EcosimPro?

Olga Asuar: Because of its great mathematical capacity, EcosimPro can simulate highly complex systems with a multitude of variables. These days, desalination plants use a large number of different processes that can easily be studied using EcosimPro. An example of this are the modern energy recovering systems with which there is not much experience, and they can be studied and optimised by using a simulation tool. Generally speaking, the advantages of using EcosimPro are the same as in any other process plant: study the behaviour without having to do tests in the plant or in pilot plants, the ability to simulate complex systems, quick results, optimised process and costs, etc.

Interviewer: How long has EcosimPro been used on these kinds of projects, and how have the results been?

OA: EA has experience using EcosimPro for simulations specifically in the field of desalination plants, for example in studying the coupling of an MED plant with a PBMR type reactor. This is a clear example of EcosimPro's capabilities in the field of simulation: it can handle the simulation of a system as complex as one resulting from coupling a nuclear reactor to a desalination plant. Some of the most noteworthy results from that simulation were the selection of the optimal number of stages for the MED plant, the selection of the best type of coupling, a study on the effect of changing variables such as the intake temperature of seawater or the effect of the variation on different energy sources.

Interviewer: One of the objectives of the Ministry of the Environment's AGUA plan is to build many more desalination plants. A bright future that will need improvements to technologies that reduce costs and increase the energy efficiency of these plants. What role can a tool such as EcosimPro play in achieving these goals?

OA: The Spanish government's AGUA plan is an ambitious program of setting up desalination plants to supply fresh water to the Mediterranean coast. EcosimPro can help meet commissioning deadlines, for example, by simulating the startup, training the personnel in charge of operations, reducing the operating costs by optimizing the process, or studying the effects from changes or enhancements to equipment and thus be able to build better-designed plants.

Interviewer: What would you highlight from using simulation and modelling in the field of desalination plants? Is it necessary? Does it contribute to increasing the useful lifetime of the facilities? Do you think there are any more aspects that still need to be developed?

OA: I would highlight the ease in handling the many variables involved in a desalination plant: flow processes of fluids, processes of separation, storage, recovery of energy, chemical dosing, water quality, etc. A tool like EcosimPro enables you handle processes with the complexity of a desalination plant and optimize it to increase its performance and the useful lifetime of the facilities.

Interviewer: Spain is currently ranked fifth in the world for installed desalination capacity. Is this good news for the future of your company in this country? Does it mean that we are better placed and have more developed technologies in comparison with other countries?

OA: Within the framework of the AGUA program, it is expected that Spain will have a desalination capacity of over 800 hm3/year by 2011, and will commission 34 new reverse osmosis desalination plants. This makes Spain the most advanced Mediterranean country in desalination using this technology, and there are good prospects for the future in the improvement of this type of installation. As far as other technologies used are concerned, Spain does not have any that are more advanced than those used in other countries, as new seawater desalination plants are being installed worldwide with the latest energy recovery mechanisms and with the latest generation membranes.

However, there is an opportunity to study some of the unknowns that still exist in new systems due to the lack of experience in their use. These unknowns include the behaviour of materials under fatigue conditions, and the small mix of liquids that occurs in some processes. Other important areas of study are the development of new materials for the membranes that have greater tolerance to fouling and/or temperature, and that have lesser requirements with regard to pressure.
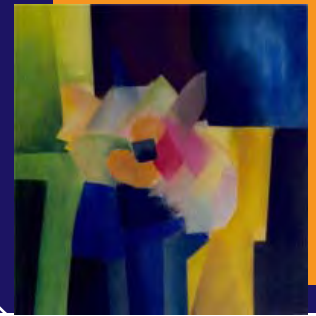
ECOSIMPRO NEWS

Galp studies the stability of the Oporto Cogeneration Power Plant with EcosimPro

Empresarios Agrupados has carried out a study of the steam stability of the boilers in a cogeneration power plant (located in the Galp refinery in Porto, Portugal) on behalf of the engineering company TechnoEdif Engenharia.

To perform the analysis, we modelled and simulated two boilers operating in parallel and two high and medium pressure refinery consumers. All the models were developed with EcosimPro.

Galp refinery in Porto (Portugal).

The aim of this study was to verify boiler operation vis-à-vis anomalous situations; for example, total failure of one of them, the possible variations in demand for steam, or a fault in the gas turbines leading to switchover from the use of turbine gases to the use of air.

The complete hydraulic system (pumps, valves, pipes, etc) was modelled using elements from the FluidaPro professional library. We also used the Fluid_Properties library to calculate the thermodynamic properties of the fluids. Moreover, the EcosimPro team has worked on the development of a specific library called HRSG (Heat Recovery Steam Generator) to simulate the elements typical of a boiler.

A very important part of the work consisted in modelling the complete process control system, for which we used the Control library.

EcosimPro is especially apposite for certain sectors like that of boiler manufacturers because although they carry out their own boiler operation studies, engineering companies also perform further analyses to study possible anomalous or hazardous situations.

In these cases, simulation tools like EcosimPro play a key role because they enable us to study the transient states that take place in the boiler system of cogeneration power plants, to optimise their performance and to ensure the chain of supply.

The book Introduction to Modelling and Simulation with EcosimPro is published

In collaboration with the EcosimPro team, the Faculty of Systems Engineering and Automatics at Cordoba University has published the book Introduction to Modelling and Simulation with EcosimPro.

The objective of this publication is to put on the market an introductory manual on the use of this tool in industrial processes.

Simulation has become a fundamental tool in many disciplines which enables product designs to be improved, the development and testing times to be reduced, and – above all – costs to be cut. Simulation tools have been used for many years in areas such as automotion, the process, chemical, energy industries, etc, and today they are a basic element of any new design.

The book gives a complete introduction to the use of this simulation tool which is of immense use in the design, development and control of industrial processes and new products.

TITLE	Introduction to Modelling and Simulation with EcosimPro
AUTHORS	Francisco Vázquez, Jorge Jiménez, Juan Garrido, Antonio Belmonte
PUBLISHER	Pearson Educación, S.A.
PAGES	272 pages
ISBN	978-84-8322-681-0
PRODUCT	004.4.Software

In addition to the printed edition on sale at El Corte Inglés, La Casa del Libro, Todobook.com, etc, a new eBook version has been released. You are also invited to visit EcosimPro's official site which has links to shops where the hardcopy or eBook can be purchased via the Internet.

PROOSIS at TURBO EXPO Turbine Technical Conference and Exposition, presented by ASME International Gas Turbine Institute

During the 2010 ASME Turbo Expo (held at Glasgow in june, 14-18 2010), the EcosimPro team presented the PROOSIS simulation tool.

Every year, the gas turbine world congress brings together leading experts and professionals to share the latest technological advances in this field. Speakers representing the most important companies attended on this occasion to address the different areas: construction, instrumentation, design, control, simulation, optimisation, etc.

Within this framework, the EcosimPro specialists gave a tutorial session on PROOSIS, showing how to model the different elements that form a gas turbine and other aeronautical systems. They also presented the TURBO library which includes all the characteristic components of aeronautical engines, such as compressors, turbines, fans, nozzles, propellers, combustion chambers, etc.

The presentation of PROOSIS' in-built capabilities related with the creation of design calculation and engine behaviour, compressor and turbine map charts, steady-state and transient calculation, calculations with closure equations and inequations, deck generation, etc, proved to be of great interest.

New version EcosimPro 4.8 available

At the beginning of September, the new version 4.8 of EcosimPro was launched in which users will find new improvements over the previous version.

Highlighted among the main improvements and new features is the possibility of working with the C++ compiler, free from GNU, which is also included in the installation.

Version 4.8 includes a new widget called GSE (Graphical Simulation Environment) to display the simulation results on the Monitor. This new capability will enhance the users' experience, enabling them to represent variable values on simulated model images and quickly access other GSEs. In addition, an alarm system has been enabled to easily detect and view variables that exceed the range defined beforehand by the user.

For users that work simultaneously with the same libraries, we have implemented a new system of messages and blocking actions by means of which the user is notified of potentially dangerous situations.

The new plots enable variables to be represented vis-à-vis two different ordinate axes, especially useful when the order of magnitude of the variables to be represented is very different. Furthermore, with the "Markers" option enabled, you can see the coordinates of any point, mark it, and even compare its coordinates with another previously marked point.

Likewise, users will find other advantages like the possibility to export data represented in tables and plots to CSV format, the possibility of saving the Workspace configuration and loading it later, new types of calculation in the experiment wizard and other functionalities.

The EcosimPro 2010 Award for the best article on research in the automatics field presented at the CEA-IFAC Congress

This year, the "EcosimPro Award" for the best article has been presented to Alejandro Merino and Luis Gómez Palacín, of Valladolid University, for their work on the applications of this tool in the automatics field.
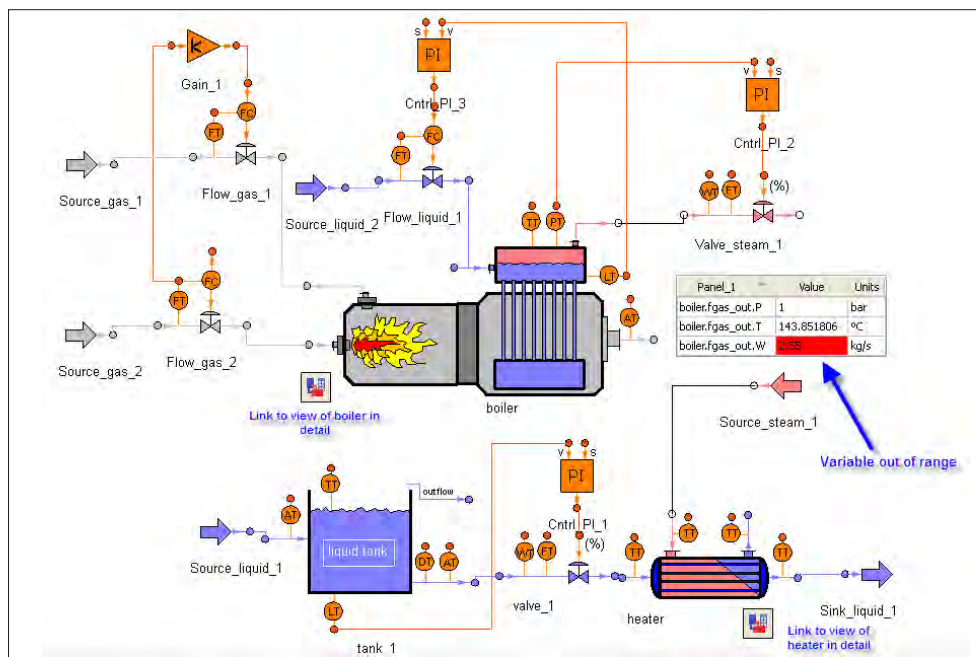
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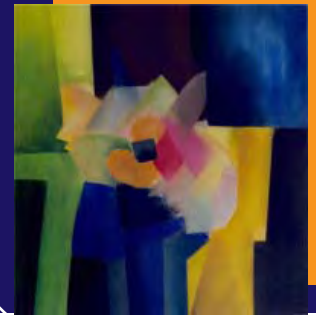
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New version of EcosimPro 4.8. The image is of a GSE in which we can see its main components, such as two navigators (links to other GSEs), a panel on which we can view the evolution of the variables and, at the same time, the alarms implemented. (Page 4)

The award for the article "Global Sensitivity Study and Estimation of Parameters in an SBR Reactor, with Nitrification/De-nitrification, Using the ASM1 Model" was presented during the 31st Conference on Automatics which was held from 8 to 10 September in Jaen, Spain. Promoted by the CEA (the Spanish Committee for Automatics), this conference has been held annually since 1977 in order to promote the study, application and enhancement of techniques in the field of automatics.

The EcosimPro team wrote a paper for this conference and presented the new capabilities of this tool and a brief description of the applications in which is has been employed.

The media echo the applications of EcosimPro

Magazines that specialise in energy – such as InfoPower and SolarNews – have echoed the applications of EcosimPro in this field. In their special issue dedicated to thermosolar energy, the former published a full technical article on the advantages of simulation with EcosimPro for optimum operation of these types of plants.

The media have also shown interest in the publication of the book Introduction to Modelling and Simulation with EcosimPro,

the participation in the Space Propulsion Conference, the new version of PROOSIS, or the collaboration of EcosimPro in the LHC at CERN. Automática e Instrumentación, Convertronic, Ejecutivos, Tecnociencia, Eurasia Review or Energías are some of the journals in which the developments and activities of the EcosimPro team have been reflected.

Conference in CIEMAT on the work of EcosimPro in the ITER

The EcosimPro team participated in some of the workshops on the International Thermonuclear Experimental Reactor (ITER) project organised by CIEMAT (Spanish Research Centre for Energy, Environment and Technology,), 23-24 September, during which we presented the role played by EcosimPro in this project.

To date, tritium transport phenomena have been modelled and simulated with TMAP7, an American code validated for this purpose. Now model validation with EcosimPro is being tested. The conclusions of LIBRETTO4 (LIquid BReeder Experiment with Tritium Transport Option) were presented at the conference, an experiment in which the results obtained with EcosimPro were compared against those obtained with the American tool and the experiment data gathered previously by different laboratories.

This study served to compare the numerous advantages of Eco-simPro vis-à-vis other tools for modelling and simulating complex systems such as those related with the ITER project.

New EcosimPro 4.8 Limited Edition now available

The new, free Limited Edition of EcosimPro 4.8 LE is now available on the Internet. It includes, for the first time, the GNU C++ compiler which is downloaded with the product and therefore greatly facilitates new users who do not already have a C++ compiler. This new version also works with Microsoft C++ compilers.

Home page update

EcosimPro's home page has been updated with new articles from users, and links to the Introduction to Modelling and Simulation with EcosimPro published by Pearson and the new EcosimPro 4.8 LE.

SUGGESTIONS

The EcosimPro Newsletters aim to be a tool for interchanging news and experience among EcosimPro users and others interested in the field of system simulations and modeling. Your suggestions regarding its contents and/or your collaboration will be welcomed.

## Enhancements to PROOSIS version 2.4

The EcosimPro team have been working for the past few months on PROOSIS version 2.4 which has new capabilities and enhancements.

The new version 2.4 was marketed in July and includes new enhancements in the areas of nonlinear equation system solving, improvements in the wizards for creating experiments, improvements in map displays, result graph displays, etc.
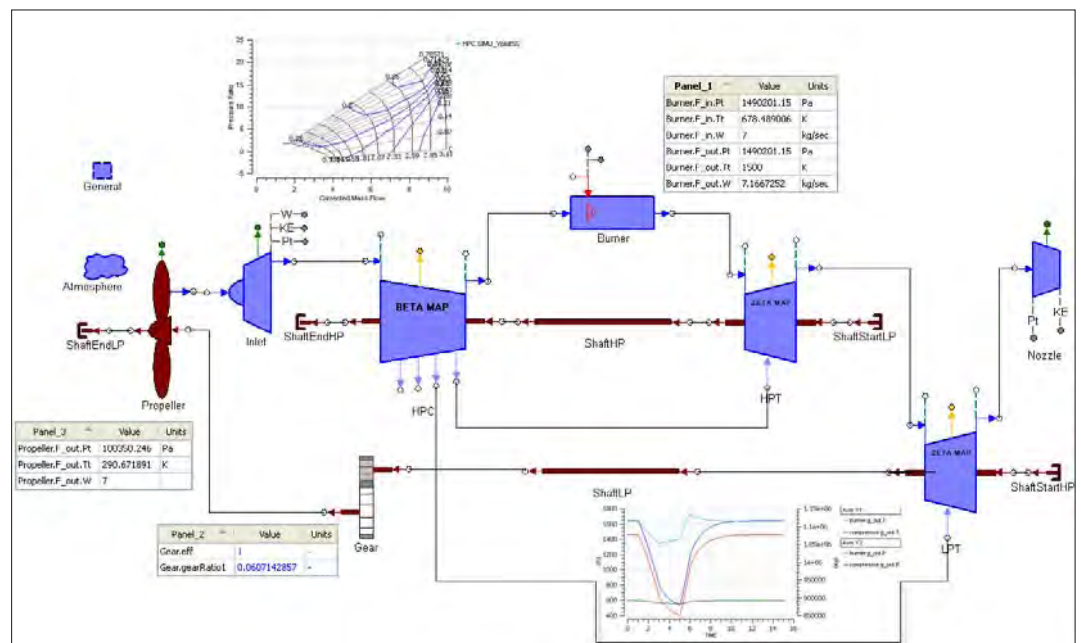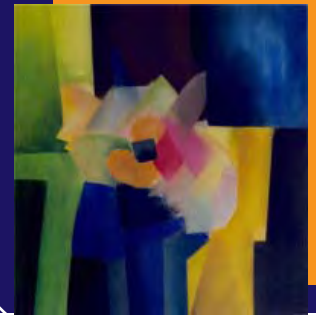
Which types of variables are there in EcosimPro?

When someone begins modelling in EcosimPro, it is very important that they know the different types of basic variables the tool provides. Basic types can be classified from two points of view:

Classification by storage variable type
From the point of view of represented data, the following basic types exist:

- **REAL**: Representing a double precision floating-point number

- **INTEGER**: Representing an integer value such as 1, 2, etc.

- **BOOLEAN**: Representing a TRUE or FALSE boolean variable

- **STRING** o **FILEPATH**: Representing a character string

- **ENUM**: Representing an enumerate variable

For example, an enumerate type is defined as Chemicals with some valid values:

ENUM Chemicals = { CO2, H2, H2O, H2SO4 }

A Chemicals type enumerate variable is defined as:

ENUM Chemicals comp= H2O

- **TABLE_1D, TABLE_2D** y **TABLE_3D**: Representing a data table in one, two or three dimensions.

Apart from these basic types, EL (EcosimPro Language) enables to work with multidimensional arrays of any of the basic types except for the tables. For example:

REAL vr[2,3]
Two-dimensional array with 6 real type values

INTEGER vi[5,6,7,9,3]
Five-dimensional array with 5670 (5*6*7*9*3) integer values

STRING vs[Chemicals]
One-dimensional array of strings with as many elements as the Chemicals enumerate contains (in the above example it had 4 elements)

Classification by mathematical variable type
In a mathematical partition, each basic variable of a component or port is assigned to a mathematical type which will define how this variable will behave in the model. The following are the mathematic types of variables:

- **CTE**: These are constants (of any basic types except tables) which cannot be modified at any time during or after simulation. They are the ones declared with the prefix CONST and the construction parameters.

- **DATA_VAR**: These are input data declared in the component DATA block.

- **BOUNDARY**: When a partition is created in a model that has more variables than equations, some of the variables must be defined as boundaries.

Like the data, the boundaries are input variables, with the difference that the data can not change during the simulation and the boundaries can be varied during the simulation if they are provided as functions of time.

- **EXPLICIT**: They are calculated explicitly for one – and only one- equation.

- **DYNAMIC**: These are output variables which have a derivative that participates in the modelling. They are variables which are calculated by numerical integration.

- **DERIVATIVE**: These are output variables and they are derivatives with respect to the independent variable (TIME by default). All derivatives automatically have an associated dynamic variable. They are calculated similarly to the EXPLICIT type.

- **ALGEBRAIC**: These are output variables which it has not been possible to explicitly calculate because either it has not been possible to solve them with any equation, or an algebraic loop has been created. They are calculated by a numerical nonlinear equation solver.

- **DISCRETE**: These are internal model variables declared in the component DECLS block and which EcosimPro is not going to calculate with solvers; that is to say, the modeller is responsible for them and they behave discretely. All variables declared in the component DECLS block and ports which are not of the REAL type are discrete.

For example, the following "tex" component:

```
COMPONENT tex ( INTEGER N= 3)
DATA
        REAL d[N] = 0.0
DECLS
        REAL x
        REAL y
        REAL z
        REAL t
        DISCR REAL r
        BOOLEAN b= TRUE
CONTINUOUS
        x' + sin(TIME) = 2.5*y + 4.5*z + d[2]
        sin(y) - 7.5*y = cos(z/2.3) - d[1]
        t = ZONE( b == TRUE) z + r
           OTHERS 0.0
END COMPONENT
```

When a default partition is created for this model, we can see in the mathematical display how all the variables have been classified:

NUM	NAME	TYPE	MATH-TYPE
1	N	INTEGER	CTE
2	b	BOOLEAN	DISCRETE
3	d	REAL[3]	DATA_VAR
4	r	REAL	DISCRETE
5	t	REAL	EXPLICIT
6	x	REAL	DYNAMIC
7	x'	REAL	DERIVATIVE
8	y	REAL	ALGEBRAIC

And the associated equations which are generated are:

```
BOX 1
        0 = sin(y) - 7.5 * y - (cos(z / 2.3) - d[1])
END BOX 1
        x' = 2.5 * y + 4.5 * z + d[2] - sin(TIME)
        t = ZONE[1] (b == TRUE ) z + r OTHERS 0
```

We can see that there is an algebraic box with an implicit equation which will be used to calculate the algebraic variable "y" and two explicit equations which calculate "x'" (DERIVATIVE) and "t" (EXPLICIT).

The "N" is an integer constant since it was a construction parameter which has taken the default value 3. "b" is a discrete boolean variable because all those which are not real are discrete.

Variable "d" is an array of 3 elements defined as input data. "r" is a discrete real variable because it was defined as DISCR REAL. Variable "t" is explicit since it is going to be explicitly calculated in an equation. Variable "x" is dynamic because its derivative appears in the component. "x" is the derivative of x with respect to time and is calculated explicitly. Variable "y" is algebraic since it could not be solved and will be calculated iteratively. Lastly, variable "z" is a boundary because the system has more unknowns than equations and EcosimPro has used it as a boundary

From the black box point of view, we could see the mathematical model as:
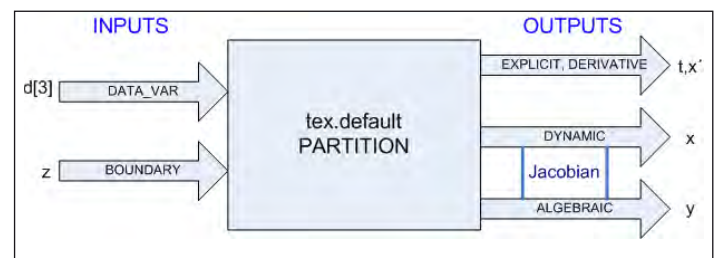
The Jacobian of this system will be formed by the DYNAMIC and ALGEBRAIC variables. In other words, in this case the Jacobian is formed by "x" and "y". The residue equation associated with the dynamic variable "x" will always be that which makes its derived variable equal to zero (x'=0) and that of the residue of the algebraic variable "y" is that which EcosimPro has written in the information of BOX 1 referred to earlier.

If a model has neither DYNAMIC nor ALGEBRAIC variables, it is said to be an explicit system and it is calculated by direct methods. If only dynamic variables exist and there are no algebraic variables, it is said to be a system of ordinary differential equations (ODE). If there are only algebraic equations then it is a system of algebraic equations (AE), and if the two types exist it is a system of differential-algebraic equations (DAE).

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