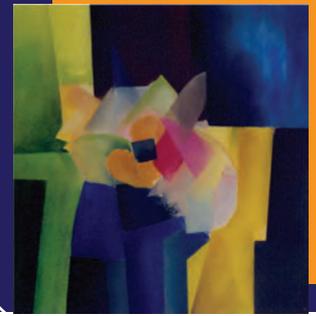


# EcosimPro

## Modelling and Simulation Software



EcosimPro · Newsletter N°4 · July 2011

## EDITORIAL



The EcosimPro newsletter No.4 is now available to users, technicians and professionals involved in simulation.

This issue includes details on the latest updates implemented in EcosimPro, including the latest developments in PROOSIS Version 2.6, the expansion of the libraries for

energy production plants, and the use of two of the libraries in the simulation of a hydraulic system for the modelling of ornamental fountains.

While this development work was going on during the last few months, we have kept up close collaboration with institutions, universities and other bodies that use EcosimPro as a modelling and simulation tool for their projects, including the ITER Tritium Plant and the improvement and updating of the CERN Cryogenic Library.

With the aim of promoting and spreading the knowledge of the many advantages of EcosimPro, Empresarios Agrupados has

continued to give diverse training courses, including the modelling of transport phenomena given at the UPC facilities.

In addition, as usual in our bulletins, this issue includes new useful articles, on this occasion based on how to use an alias in EcosimPro and on how to export EcosimPro models as black boxes.

Lastly, with the purpose of analyzing in detail how users and experts can best use EcosimPro, there is an interview with Ramón Pérez Vara, engineer in the Applied Mechanics Department at Empresarios Agrupados, who analyzes the application of this powerful tool and its main characteristics.

We hope that this new communication channel continues to be a source of good information on EcosimPro and on the continuous improvement work that the team carries out, as well as a contribution to the development and improvement of modelling and simulation in general.

Pedro Cobas Herrero

Head of the EcosimPro Development Team

## ENTREVISTA



**Ramón Pérez Vara**

**Engineer in the Applied Mechanics Department of Empresarios Agrupados**

**“EcosimPro/ESPPS was fundamental when it came to designing the regulator in the PSA project”**

Ramón Pérez Vara holds an M.Sc. in Aeronautical Engineering from the Madrid Polytechnic University (UPM). His professional career at Empresarios Agrupados began in 1978, when he was entrusted with performing thermal-hydraulic analyses on nuclear power plant systems. Since then he has worked on numerous equipment simulation and development projects of particular importance.



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**Question:** Anticipating a possible resurgence of the nuclear industry, EA has formed an ‘excellence group’ which you are part of: what are the objectives of this group in the medium/long term future?

**Ramón Pérez Vara:** Yes, EA is positioning itself for the expected change in tendency with regard to the nuclear industry on a national and international level. The work we expect to be doing in the medium/long term will not involve detail engineering nor any thermo-hydraulic calculations using licensed programs (Appendix K); rather it will involve consultancy work. Our main objective is to be prepared to offer these services with the highest possible quality and the lowest possible cost. To achieve this goal we have set up an ambitious in-house training programme, and a separate programme for the maintenance and updating of the relevant software.

**Q:** Nuclear power plants generate a series of thermo-hydraulic situations that differentiate them from conventional power plants, and which must be strictly controlled. What are these differences and what requirements are imposed by the regulatory authorities?

**R. P. V.:** In order to build or manage a nuclear power plant, the applicant (a utility) must present a Safety Analysis Report. This document contains the design information and the design criteria of the plant, as well as relevant data on the proposed site, and it has to demonstrate the safe behaviour of the plant under any circumstances. In a nuclear power plant there are many thermo-hydraulic situations that do not exist in conventional power plants, such as two-phase flows, metal-water reactions, etc. All these situations have to be studied, documented and sent to the regulatory authorities.

**Q:** What is the relevance of “best-estimate” simulations in the license analyses and in the emergency operating procedures?

**R. P. V.:** Licensing codes are by nature very conservative. However, there is a modern tendency to ask if the sum of a lot of conservative assumptions may actually lead to a non-conservative scenario; this sometimes can happen. This is the reason why “best-estimate” simulations tend to be included in the license analysis. On the other hand, it really is necessary to include “best-estimate” simulations in the emergency operating procedures of a nuclear power plant, because it is necessary to know the “real situation” of the plant.

**Q.:** Simulation tools allow users to place themselves in scenarios

that previously could not be analyzed. After the events at Three Mile Island (TMI), Chernobyl and Fukushima what do simulations tools have to offer so that these events are not repeated?

**R. P. V.:** From the lessons learned from TMI, Chernobyl and Fukushima the maturity of the nuclear industry and the development of quality assurance has exponentially increased the scenarios or events that can be analyzed. In order to analyze the different operating scenarios in a nuclear power plant, computer tools have to be robust, powerful and simple. Almost all thermo-hydraulic processes can be simplified by linearization and can be represented by ordinary and algebraic differential equations. That is where the power of simulation tools comes in, as it allows users to create their own libraries of simulation models and to use the calculation models. Another issue is the final licensing analyses, which require accepted tools in accordance with the nuclear legislation.

**Q.:** Are simulation tools sufficiently advanced to be of use to nuclear power plants? Are there any specific situations for which said tools have to be modernized?

**R. P. V.:** Most of the tools currently available for the analysis of the normal operation and incidents in nuclear power plants were developed for the purpose of carrying out the Safety Analyses required to obtain the construction and operation permits for said power plants, ie licensing. The tools are very advanced from the point of view of the modelling of the phenomenon and applied numerical solution, but not from the point of view of ease of use.

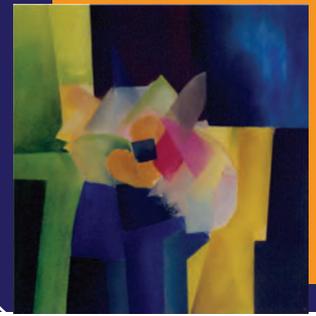
The reason they are difficult to use is that they have not evolved much ever since the nuclear moratorium in the late 70’s and early 80’s in most Western countries. They are tools for very detailed analyses, very complex mathematically speaking, and do not have friendly user interfaces, as the PC had not yet been developed at that time.

The use of these tools was therefore slow, and much time was required for the construction of the models and to analyze the results; they are not really suitable for the first phases of a nuclear renaissance. At the present time there is a lack of tools for analysis of designs prior to licensing.

**Q.:** When you were at IberEspacio, what project was most significant for you? The ESPSS library is reference point for the aerospace industry; could you provide an outline of its main uses and characteristics? What other specific libraries have been developed?

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**R. P. V.:** It's difficult to mention just one Project, as in general all the space projects developed by IberEspacio are of great Technical interest; but nevertheless, here are a few hardware projects that stand out:

- Development of cooling devices for satellites (heat pipes and cooling circuits by capillary pumping)
- Development of the propellant Supply Assembly (PSA) which is a Pressure regulator for the electrical propulsion System of the Small GEO satellite

The use of EcosimPro was fundamental in all these projects in order to be able to predict and estimate the operating characteristics of these systems

Apart from the hardware projects, there are other pure software projects, including the ESPSS.

ESPSS is a set of EcosimPro libraries developed to allow the simulation of space propulsion systems (chemical rocket motors, electrical propulsion systems, propulsion fuel tanks, valves, combustion chambers, etc). The client is the European Space Agency (ESA) and the goal is to develop a standard tool that can be used by the whole European space industry.

**Q.:** What advantages are there in the use of this library and why was EcosimPro chosen as the basis of the development? What are the most outstanding features of this tool?

**R. P. V.:** ESA chose EcosimPro for two reasons: its flexibility in introducing new models and because it was an open system where the users can incorporate new blocks of basic modelling into the libraries. In this way, propulsion companies can adapt the tool to their own needs by incorporating their prior technical knowledge. The advantage for the European space industry was in obtaining a common tool at a very low Price, by which companies can supply and Exchange their models. The previous situation was very inefficient as each company has to develop its own tools, the costs were fairly shared, and it was not possible to exchange models as the companies' tools were not compatible with each other.

**Q.:** What features of EcosimPro are especially noteworthy (ease of use, operation, interface, etc)?

**R. P. V.:** I would point out three fundamental characteristics:

1. Flexibility for modelling any class of hydraulic, mechanical, electrical,

thermal or nuclear system; it allows the engineer to develop libraries of reusable models representing all these types of systems

2. It allows transfer of technical knowledge within the company. The engineer developing the libraries needs to have good knowledge of the equations representing the behaviour of the equipment, and of the numerical solver available in EcosimPro. These libraries can then be used by engineers with less experience to construct representative models

3. The possibility of carrying out inter-disciplinary simulations. Usually, simulation tools allow the analysis of just one type of system: hydraulic or electrical or mechanical, but in real life a system interacts with another type of system, and a single-discipline tool only allow the representation of one part of the overall system, ie just the hydraulic or mechanical or electrical part. EcosimPro does not have this limitation and allows analysis of the entire system.

**Q.:** Out of all of Ecosimpro's numerous applications, which are the most notable in the aerospace sector?

**R. P. V.:** EcosimPro has two libraries for the aerospace sector: ECLSS and ESPSS and both have years of development behind them.

ECLSS is a library for the simulation of spacecraft systems of the same name. ECLSS stands for Environmental Control and Life Support Systems. These systems are responsible for maintaining the life and comfort of the crew in spacecraft, and include subsystems for the management of air (production of oxygen and elimination of CO<sub>2</sub>), of water and the recycling thereof, and of waste.

**Q.:** Could you provide more details on the PSA Project that IberEspacio is currently finishing up, and what it's first industrial application will be?

**R. P. V.:** It's a xenon gas Pressure regulator for the propulsion System of small telecommunications satellite (small GEO) that is being developed by the European aerospace industry. It is a high-precision regulator and with regulation capacity over a very wide flow range, as the regulator not only has to supply the electrical propulsion, but also a cold propulsion system with a flow demand that is much greater than that of the electrical propulsion.

EcosimPro/ESPSS was a fundamental tool for the design of this regulator, for the specifications of the control electronics, for predicting the results of the tests and for correlation of the test results.

## LATEST NEWS ECOSIMPRO

### Simulation of the ITER Project Tritium Plant using EcosimPro

Empresarios Agrupados, in collaboration with CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas) and using EcosimPro, is working on the development of libraries for the ITER (International Thermonuclear Experimental Reactor) Project Tritium Plant.

The purpose of this plant is to recover as much tritium as possible from the liquid and gaseous effluents, as it is the fuel of the fusion reactor. This process is defined by the strict requirements imposed by ITER with regard to the containment of this gas in the installations.

The availability of a simulation model will allow some of the main problems facing the future fusion reactor to be resolved, both in terms of design and of operation – for example, for the control of the tritium inventory in the different plant systems.

The difficulty of these studies lies in creating a model that faithfully reproduces the tritium transfer phenomena through different materials.

The first step was to successfully validate the capability of EcosimPro for the simulation of these types of models in comparison to other qualified tools such as TMAP7 (The Tritium Migration Analysis Program).

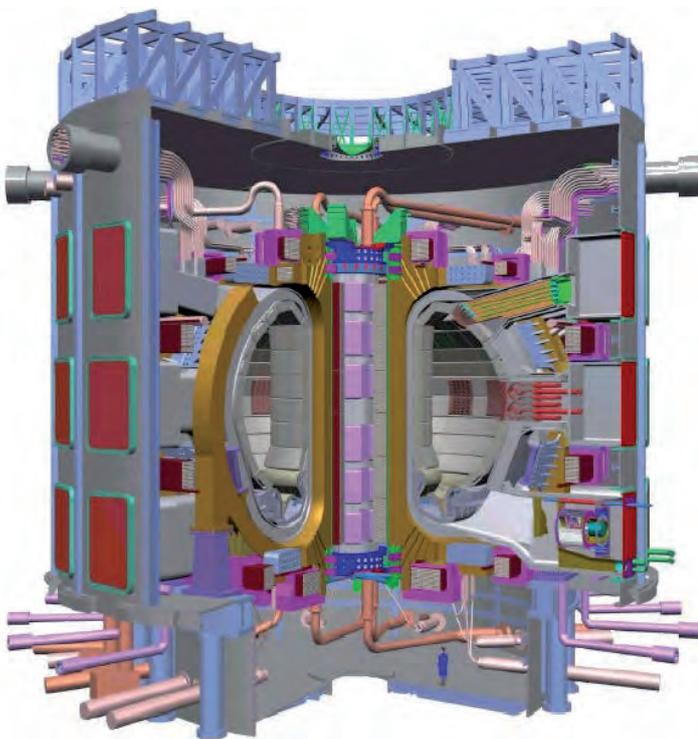
At the present time we are working on the development of libraries containing models that can be used to simulate the different equipment items that comprise the tritium plant. These libraries will take into account material transfer phenomena, as well as hydraulic, thermal, phase equilibrium phenomena, etc.

Using these simulation models it will be possible to explore new control strategies, optimize the design of the control and management of the plant, and carry out different studies, and assist in the training of operation and maintenance personnel.

### Researchers at CIEMAT continue with their EcosimPro training courses at the UPC (Universitat Politècnica de Catalunya)

TecnoFus, Institut de Recerca en Energia de Catalunya (IREC), Fundació b\_Tec, management leader of the Campus Diagonal-Besòs, and Empresarios Agrupados organized a course on EcosimPro and modelling of transfer phenomena at the facilities of the UPC (Universitat Politècnica de Catalunya BarcelonaTech).

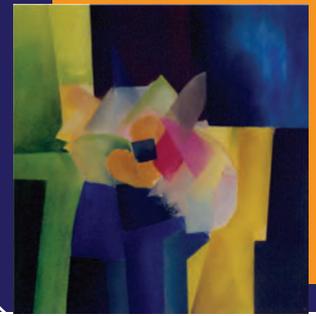
The purpose of the course, which was given on 27th and 28th April, was to provide training to the researchers working at CIEMAT (Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas), at the UPC, at the IQS University Centre, and at IREC, on the modelling of transfer phenomena (tritium, hydrogen, deuterium, etc) using EcosimPro.



ITER kernel.

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The course attendees were able to see the application of EcosimPro, a versatile simulation tool, to their different areas of work (ITER Test Blanket Modules, hydraulic circuits, thermal analyses, etc).

### EcosimPro improvements in Version 2.6 of the PROOSIS simulation tool

Over the last few months the EcosimPro team has been working on Version 2.6 of PROOSIS which now has new capabilities and improvements. These include the option of using several layers in the schematic



diagrams, which allows users to group numerous elements and to view the ones that belong to one or more layers. This option is especially useful in large models as different parts of the model can be easily differentiated.

Another novelty is the new use of the capabilities of importing and exporting workspaces, now handled in separate files, which allows the exchange of different workspaces between users.

Also, improvements in Version 2.6 provide the ability to reuse existing cases and calculations in other models in the experiment generation wizard. In addition, version 2.6 makes available to the user additional methods for managing documents, nodes and attributes, as well as a

new xml parser, which can be used in components and/or experiments. Lastly, the EcosimPro team has improved the visualization of maps – in addition to the existing basic types, the new concept of subtype for the reuse of these basic types has been added.

### EA expands EcosimPro libraries for energy production plants

Empresarios Agrupados is working on the development of two component libraries in EcosimPro for the simulation of static models (heat balances) and transients in energy production plants. Both libraries will be compatible among themselves so as to allow the user to combine in the same model purely static components with others that contain a detailed representation of the dynamics of the process.

It should be noted that a component is a sub-model that represents an equipment item or sub-system of the plant, such as for example the sub-models of feedwater heaters, turbines, valves, piping, etc. An item in the real system can be represented by different components with differing levels of detail.

Components allow modelling of steam and gas cycles, and are applicable to steam, solar-thermal, combined cycle and nuclear power plants.

The ultimate goal of these libraries is to allow a continuous evolution of models and their degree of detail during the development of the project of a new plant. In this way, there is no need to change tools and it facilitates the reuse of the information in the heat balance and dynamic models

### Simulation of fountains

The Water and Art Department at GHESA, which is dedicated to the design, manufacture and installation of fountains and water and light elements for artistic and ornamental purposes, is using EcosimPro to simulate different water-firing systems for their fountains.

For the multi-disciplinary modelling of these systems, the two-phase flow library called FLUIDAPRO and the control block library called CONTROL are being used.

After a validation phase against the performance of a real system prototype, the simulation model will allow improvement of the

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Multimedia Fountain in Brasilia.

design of these systems, adjustment of the control parameters for the firing sequence and optimization of energy consumption.

### Updating and improvement of the cryogenic library, in collaboration with CERN

Since February, Empresarios Agrupados, in collaboration with CERN (Centro Europeo de Investigación Nuclear), has been developing a project for the improvement of the CERN cryogenic library, used in the simulation of the cooling system of the super-



One of the eight, 18 kW cold-boxes at 4.5 K, used in the LHC.

conducting magnets of the LHC (Large Hadron Collider).

The project consists of expanding the library to provide it with new capabilities, such as the consideration of back-flow in components, the improvement of the algorithms for accessing property tables, the expansion of the system fluids (like nitrogen, oxygen, hydrogen, argon, etc) and the introduction of new components.



LHC tunnel .

The goal of this collaboration is to create a universal cryogenic library that can be adapted to differing cryogenic systems. This has been demonstrated by CERN this is especially interesting for the development of control systems for said systems, as it allows control engineers to have a model that reproduces real behaviour on which to apply different strategies. In addition it allows them to observe the effects on the plant as a whole and to attain robust control, without having to use the real system, which is expensive and in many cases impossible if it is in operation.

The generated model can be exported in C++ in order to connect it directly to the real control system or in order to develop the control algorithms in EcosimPro. In addition, exporting models from EcosimPro allows the maximum development of the software's capabilities. An example of this is the training simulator for operators developed by CERN, which is exactly the same as the real control centre, but which internally processes the model developed in EcosimPro.

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## FAQs: How to use an Alias in EcosimPro



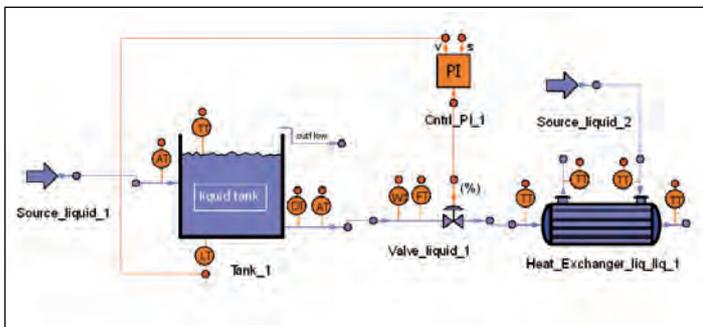
When a person used to working with real systems starts working in simulation, an important aspect is that the variables in the simulation model should be the same as those used in the real System.

In this way the user is capable of rapidly finding the variables that are of interest and can start working in an efficient and comfortable manner.

EcosimPro allows the user to assign an identification ‘alias’ to the original variables in the simulation model, so that once assigned, the user can work using the alias.

Imagine the following scenario:

There is a liquid stream, in this case water, entering a tank where the



level can be controlled, and which passes through a heat exchanger to modify its temperature.

The temperature of the stream of liquid entering the system stays constant until it reaches the heat exchanger. So it can be very useful to assign an alias to this variable and work with a single name in the partition, in the experiment and in the monitor.

There are two wizards through which an alias can be assigned: the “Schematics Properties Wizard” and the “Partition Properties Wizard”. Let us assign the alias “T\_water” to the “Tank\_1.T” variable.

From this point on, both the temperature calculated in the tank (“Tank\_1.T”) and all the variables equivalent to it will have “T\_water” as an alias.

Component	Variable	Alias	Visible	Trace	Description
Tank_1	P_outflow_calcul...		<input checked="" type="checkbox"/>	<input type="checkbox"/>	outflow pressure calculation
Tank_1	Pg		<input checked="" type="checkbox"/>	<input type="checkbox"/>	pressure of the gas phase (bar)
Tank_1	Q		<input checked="" type="checkbox"/>	<input type="checkbox"/>	loss of heat (kJ/s)
Tank_1	Rho		<input checked="" type="checkbox"/>	<input type="checkbox"/>	liquid density (kg/m <sup>3</sup> )
Tank_1	Rho_L		<input checked="" type="checkbox"/>	<input type="checkbox"/>	initial liquid density (kg/m <sup>3</sup> )
Tank_1	S		<input checked="" type="checkbox"/>	<input type="checkbox"/>	tank cross section (m <sup>2</sup> )
Tank_1	T	T_water	<input checked="" type="checkbox"/>	<input type="checkbox"/>	liquid temperature (°C)
Tank_1	T_L		<input checked="" type="checkbox"/>	<input type="checkbox"/>	initial temperature (°C)
Tank_1	Tenv		<input checked="" type="checkbox"/>	<input type="checkbox"/>	environment average temperature (°C)
Tank_1	U		<input checked="" type="checkbox"/>	<input type="checkbox"/>	overall heat transfer coefficient tank - environment (kW/m <sup>2</sup> °C)

Now the alias will appear when a partition is generated and in any experiment created, and in all the plots, tables, watches, reports, etc.

Below we can see how the alias has propagated in the creation of a plot.

Name	Units	Initial value	Type	Category	Alias
T_water	°C	0	REAL	DYNAMIC	T_water
T_water'		0	REAL	DERIVATIVE	T_water

The variable with the alias “T\_water” is a dynamic variable, and it can be seen how a derived type variable with the same name (“T\_water'”) has

also been created. The rest of the equivalent variables, as can be seen in the following figure, are identified with the same alias:

Name	Units	Initial value	Type	Category	Alias
Tank_1.T	°C	0	REAL	DERIVATIVE	T_water
Heat_exchanger_liquid_1.in.T	°C	0	REAL	DYNAMIC	T_water
Tank_1.T	°C	0	REAL	DYNAMIC	T_water
Tank_1.out.T	°C	0	REAL	DYNAMIC	T_water
Tank_1.outflow.T	°C	0	REAL	DYNAMIC	T_water
Valve_liquid_1.in.T	°C	0	REAL	DYNAMIC	T_water
Valve_liquid_1.out.T	°C	0	REAL	DYNAMIC	T_water
[Out_P1.T]	°C	0	REAL	DYNAMIC	T_water
[Out_P1.deriv]	°C	0	REAL	DYNAMIC	T_water
[Out_P1.T]	°C	0	REAL	DYNAMIC	T_water

This simple example shows the great usefulness of use of an alias in simulation models, to refer to equivalent variables in a system using the same identification or to a variable that has a very standardized identification in a real system.

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## How do we export EcosimPro Models as Black Boxes?



EcosimPro 4.6 incorporates the capability to encapsulate and export a model in the form of a black box in such a way that it contains all the information necessary for use by the end user. This enables the black box user to perform simulations on the exported model without needing to have EcosimPro installed.

This black box which encapsulates the partition and experiment is called a deck, and its main feature is that it hides the model variables that are not defined as inputs and/or outputs.

As illustrated in the example given throughout this article, the deck generator is sufficiently powerful to define which variables end deck users will have available for read and/or write purposes, and also to enable them to define the type of calculation to be performed (transient or steady state), to decide whether or not to save the simulation results, etc.

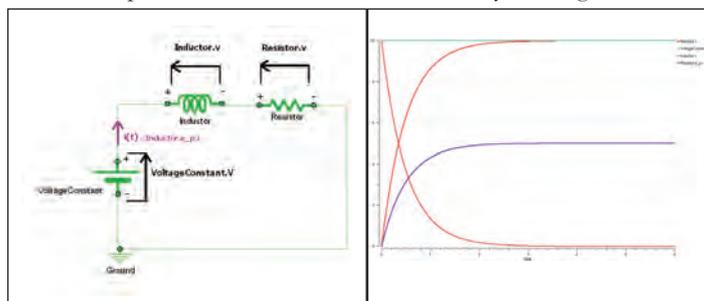
The deck can be used in three different ways:

- as an end user program without graphical interface
- as an end user program with graphical interface
- as a binary in library form for programming use with C and/or C++

In the first two cases, execution is based on defining a configuration file (in graphical form in the second case) which is read always at the start and contains the values for the inputs and the names of the variables whose final values we want to know (outputs).

### EXAMPLE OF USE

The first step is to create the model. We do this by creating a new sche-



1-a

1-b

matic diagram in the ELECTRICAL\_EXAMPLES library, and using the components in the ELECTRICAL library we build a circuit like the one illustrated in figure 1 a. Once designed, the component names and the associated data values can be changed (in this case we have selected 10 V power supply, winding 1, inductor H, and 1 Ohm resistor) using the attributes editor included in the schematics editor.

A new partition is created by default in the new component, and a new experiment is created in the partition. When we run the experiment created by default, results similar to those shown in figure 1 b are obtained.

Although this same experiment could be used to generate the deck, it is advisable to modify it in order to make the model as flexible as possible to satisfy the following assumed requirements for use by the end deck user:

- Deck users should have the capability to change the value of the constant source voltage. They should also be able to access the voltage drop value (simulation result) in the resistor and in the winding, and the circuit current
- Deck users should have the capability to select the type of simulation to be performed — transient or steady state response. In the case of the transient calculation, users will be able to modify the integration parameters (initial time, final time, and communication interval)
- Encapsulated model users will be able to decide whether or not to save the simulation results in a text file

A deck created on the basis of the following experiment will satisfy the above demands:

```
EXPERIMENT exp2 ON example_programmatic_deck.default
DECLS
STRING switch_calculation="TRANSIENT"
STRING switch_report="NO"
REAL input_TSTOP=6
REAL input_TIME=0
REAL input_CINT=0.01
INIT
-- initial values for state variables
Inductor.i = 0
```

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### BOUNDS

### BODY

```

IF (switch_report=="YES") THEN
    REPORT_TABLE("reportAll.rpt", "*"*)
    -- report results in file reportAll.rpt
ELSE
    -- do not write results file
END IF
IF (switch_calculation=="TRANSIENT") THEN
WRITE("TRANSIENT calculation selected\n")
    TIME    = input_TIME
    TSTOP   = input_TSTOP
    CINT    = input_CINT
INTEG()
ELSEIF (switch_calculation=="STEADY") THEN
WRITE("STEADY calculation selected\n")
    STEADY()
ELSE
    INTEG_CINT()
END IF
END EXPERIMENT

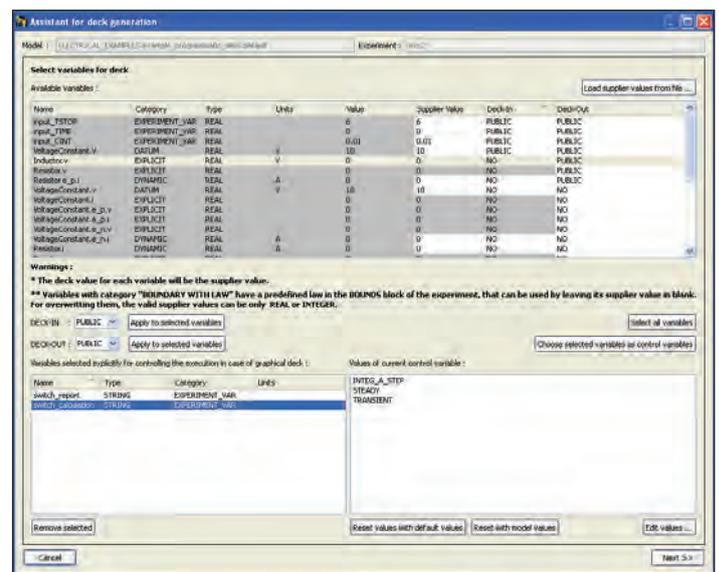
```

Using the STRING type variables “switch\_calculation” and “switch\_report”, we select the type of calculation and decide whether or not the results of all the variables are to be written to a file. The real variables input\_TIME, input\_STOP and input\_CINT will enable the internal variables for configuring the integration-in-time part to be controlled.

Once the experiment has been compiled, it must be executed at least once to verify correct simulation and to generate some information which will be used by the deck generation wizard. At that moment we can generate the encapsulated model by selecting the associated option from the contextual menu of our experiment or from Tools. It is now when we select the deck variables whose values users will be able to change (Deck-In = PUBLIC) and whose values will be available to them (Deck-Out = PUBLIC).

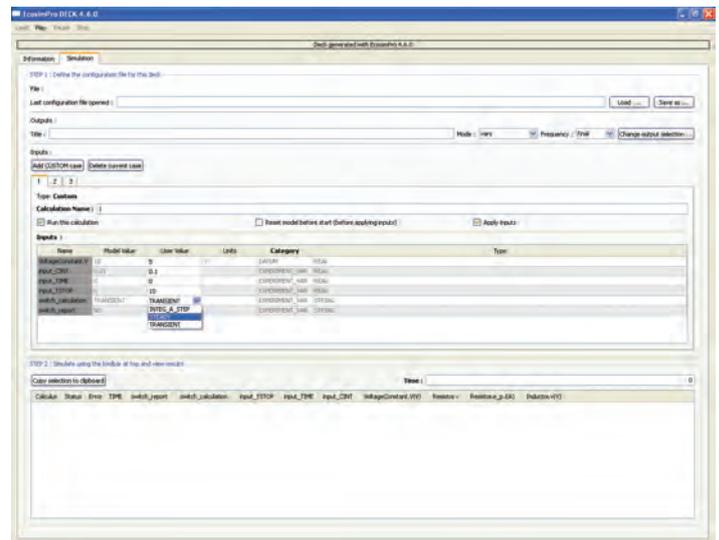
As we can see in the following figure, in addition to configuring these variables, switch\_calculation and switch\_report have been selected as control variables, and they have been assigned STEADY/TRANSIENT/ INTEG\_A\_STEP and YES/NO, respectively, as possible values. After selecting the type of deck (graphic/not graphic) and the platform on which it will be compiled, the creation process is finalized.

The deck is generated as a directory structure under the directory of the associated experiment, but after it is created it can be located outside the modelling library and can be executed totally independently,



even if EcosimPro is not installed. During its creation, the user can choose between a set of destination platforms.

The graphic deck is shown in the following figure:



The user can define different calculations, and in each one can change the input data and select the type of calculation by means of the previously configured control variables. The results of the simulation are shown in the lower part of the window after executing the model.

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