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ECO-BOND GRAPHS: AN ENERGY-BASED MODELING FRAMEWORK FOR COMPLEX DYNAMIC SYSTEMS

WITH A FOCUS ON SUSTAINABILITY AND EMBODIED ENERGY FLOWS

Rodrigo D. Castro[a,c], François E. Cellier [b], Andreas Fischlin[c]

[a]CONICET and Computer Science Dept., University of Buenos Aires, Argentina. [b]Computer Science Dept., ETH Zurich, Switzerland. [c]Dept. of Environmental Systems Sciences, ETH Zurich, Switzerland

ABSTRACT:

This article presents a general methodology for modeling complex dynamic systems, focusing on sustainability properties that emerge from tracking energy flows.
We adopt the embodied energy (*em*ergy) concept that traces all energy transformations required for running a process. Energy can therefore be studied in terms of all energy previously invested up to the primary sources, and sustainability can be analyzed structurally.
These ideas were implemented in the bond graph framework, a modeling paradigm where variables are explicitly checked for adherence to energy conservation principles.
We introduced the new Ecological Bond Graphs (EcoBG) along with the EcoBondLib Modelica library.
EcoBG represent systems in a three-faceted fashion, describing dynamics at their mass, energy, and *em*ergy facets. EcoBG offers a scalable formalism for the description of *em*ergy *dynamic* equations (resolving some mathematical difficulties present in their original formulation) and new capabilities for detecting unsustainable phases not automatically discovered when using the *em*ergy technique alone.

Dr. Rodrigo D. Castro

Prof. Dr. François Cellier

Prof. Dr. Andreas Fischlin

ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

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Department of Environmental Systems Science

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