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# Study and Implementation of Compact Modeling Techniques for the Energy Analysis and Optimization of Complex Systems

By

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Alberto Bocca
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# Study and Implementation of Compact Modeling Techniques for the Energy Analysis and Optimization of Complex Systems

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In an increasingly rich world of complex systems (e.g., in physics, biology, economics, and social sciences), the general trend is to analyze and predict certain phenomena using accurate models (e.g., neural networks) that are also complex. For this reason, apart from the basic structure, such models are neither easy to build nor to understand in all details, as they often require many functions and a large number of coefficients, mathematically speaking, even significant computational resources. Instead, this work attempts to restore simplicity by defining compact models that are easy to use, considering energy as the application area of this research. In particular, the models described in this document concern battery consumption, efficiency in the use of a network of electric vehicle charging stations, and solar energy analysis.

Regardless of whether the initial modeling approach is purely mathematical or programming-based, the real goal is always to obtain simple analytical expressions that can satisfactorily describe the characteristics of the processes and systems under test. Although it cannot be assumed that there is a compact model or a general solution for every complex system, the research results confirm that in several cases it is possible to create compact models that are more practical to use. In this way, a larger number of people can access the basic analysis of the available data in a given scenario. The creation and sharing of such models allow a better understanding of the phenomena under consideration, in particular the identification of the parameters that most influence the overall behavior of a given system and the degree of their correlation with it.

Before describing the applications, general guidance is given on the compact modeling method used here. Then, the accuracy of the proposed models is analyzed by comparing the results with those obtained with more sophisticated methods and tools or directly with experimental data.