

Coral Calero · Mario Piattini *Editors*

# Green in Software Engineering

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# Preface

## Overview

Sustainability is being demanded by our society today; we have become aware of the need to cut down on our energy consumption and reduce our carbon footprint. At an international level, there is a whole host of initiatives trying to tackle these issues, and the main research and development programmes include sizeable amounts of funding for projects seeking to achieve environmentally sound technologies.

Information technology (IT) is a key component in reaching the above goals. The use of IT in obtaining systems that are more ecological (*Green by IT*) has indeed been seen to be significant, contributing to virtual meetings, dematerialization of activities, improvement in logistics, intelligent transport systems, smart grids, more sustainable management of (smart) cities, etc. We must be aware, however, that IT also has a negative impact on the environment (the amount of energy consumed by engineering equipment, processes and services). With this situation as the backdrop, there have been major efforts (*Green in IT*) made to reduce the energy consumption of the ‘hard’ part of IT (green data centres, green hardware, etc.). Even so, it has not been until recently that research has begun to be undertaken into how to achieve sustainable software (*green in software*) alongside sustainable software engineering (*green in software engineering*).

It is our firm conviction that we, as software researchers and professionals, are under an obligation to make those in positions of responsibility in government and in our organizations aware of the issues involved here. It is all about the vital importance of obtaining models, methods and tools that reduce the environmental impact both of the software life-cycle processes and of the software products that come into being as a result of those processes.

Good books dealing with the issue of Green IT already exist; in this work, we want to make our own small contribution to the attempt to raise the profile of green in software engineering. We want to make sure that it gets the consideration it deserves. To that end, we have brought together the main researchers in the field on this matter.

## Organization

The book is composed of 13 chapters, structured in 5 parts that can be used as ‘reading paths’.

The first part (Introduction) comprises one chapter written by Coral Calero and Mario Piattini, which introduces the main general concepts related to Green IT, discussing what green *in* software engineering is and how this is different from green *by* software engineering.

The second part (Environments, Processes and Construction) consists of three chapters. Green software development environments is discussed in Chap. 2 by Ankita Raturi, Bill Tomlinson and Debra Richardson. Chapter 3 describes a green software engineering process developed by Stefan Naumann, Eva Kern and Markus Dick. Green software construction, discussed by Fei Li, Soheil Qanbari, Michael Vögler and Schahram Dustdar, is the topic of Chap. 4.

The third part (Economic and Other Qualities) contains Chap. 5, contributed by Patricia Lago, Giuseppe Procaccianti and Héctor Fernández, which proposes using the  $e^3$ value technique to model and perform trade-off analysis between alternative green practices, particularly from an economic perspective. Chapter 6 by Juha Taina and Simo Mäkinen, which presents a layered model that gives some background, offers suggestions about measuring how well software supports green software engineering and software engineering for the planet.

The fourth part (Software Development Process) begins with a proposal by Birgit Penzenstadler (in Chap. 7) for incorporating environmental sustainability as an objective in requirements engineering from the very start, by using a reference artefact model. Chapter 8, written by Macario Polo, discusses how different approaches of test design and test execution may have an impact on the consumption of energy. Chapter 9, written by Ignacio García-Rodríguez de Guzmán, Mario Piattini and Ricardo Pérez-Castillo, presents useful techniques, tools and practices for improving software sustainability in existing software systems. In Chap. 10, Coral Calero, M<sup>a</sup> Ángeles Moraga, Manuel F. Bertoa and Leticia Duboc show how to include green aspects of a software product within its quality, while Chap. 11, written by M<sup>a</sup> Ángeles Moraga and Manuel F. Bertoa, presents the main measures for green *in* software engineering.

The final part (Practical Issues) begins with Chap. 12, in which Qing Gu, Patricia Lago and Paolo Bozzelli propose a decision-making model for adopting green ICT strategies, while Chap. 13 by Martin Mahaux and Annick Castiaux discusses the participation and open innovation in/for sustainable software engineering.

As the reader will realize, we have tried to follow the structure of the SWEBOK,<sup>1</sup> attempting to cover most of the key areas (KAs) involved in the incorporation of green aspects in software engineering. In Table 1, we summarize in which chapter the content of the corresponding KA is covered (directly or indirectly).

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<sup>1</sup>SWEBOK V3.0. Guide to the Software Engineering Body of Knowledge. Bourque, P. and Fairley, R.E. (eds.), NJ., IEEE Computer Society. 2014.



**Table 1** The book chapters and the SWEBOK KAs

KA number	SWEBOK KA	Chapters numbers
1	Software Requirements	7
2	Software Design	8
3	Software Construction	2, 4
4	Software Testing	8
5	Software Maintenance	9
6	Software Configuration Management	–
7	Software Engineering Management	–
8	Software Engineering Process	2, 3, 13
9	Software Engineering Models and Methods	12
10	Software Quality	6, 10, 11
11	Software Engineering Professional Practice	12
12	Software Engineering Economics	5
13	Computing Foundations	
14	Mathematical Foundations	
15	Engineering Foundations	

We have created a keyword cloud (see Fig. 1) where the most frequently used terms in this book are written in larger letters, thus showing the areas the book focuses on.



**Fig. 1** Terms cloud (created with [www.wordle.net](http://www.wordle.net))

## Audience

The audience for this book is software engineering researchers (professors, PhD and postgraduate students, industrial R&D departments, etc.), as well as practitioners (chief information officers, corporate social responsibility professionals, software quality engineers, etc.) who want to know the state of the art as regards green in software engineering.

The reader is assumed to have previous knowledge of software engineering.

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Ciudad Real, Spain  
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**Part I**  
**Introduction**