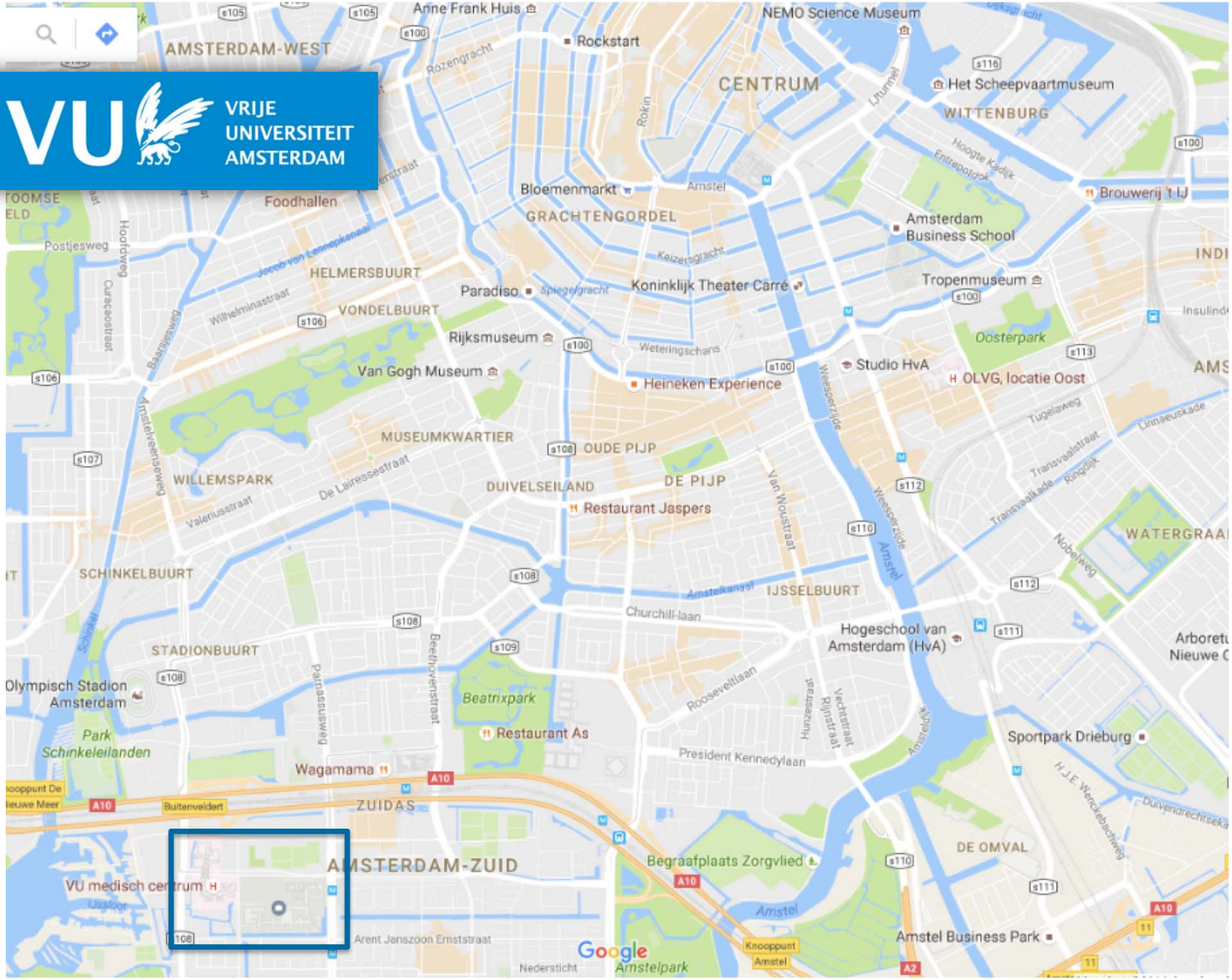
HOW DO WE MANAGE OUR (NATURAL) RESOURCES?
LINKING KNOWLEDGE WITH SUSTAINABLE CHANGE
SCIENCE FOR SUSTAINABILITY
THE LEGACY OF UNSUSTAINABLE SOFTWARE
@patricia_lago
VU VRIJE UNIVERSITEIT AMSTERDAM
LOOKING FURTHER
ILLUSTRATION: VU STRATEGIC PLAN, VISION 2015-2020


VU
VRIJE
UNIVERSITEIT
AMSTERDAM
AMSTERDAM-WEST
Anne Frank Huis
Rockstart
NEMO Science Museum
CENTRUM
Het Scheepvaartmuseum
WITTENBURG
Rozengracht
Rokin
Bloemenmarkt
Amstel
GRACHTENGORDEL
Foodhallen
Brouwerij 't IJ
Amsterdam
Business School
Postjesweg
HELMERSBUURT
Keizersgracht
Paradiso
Spiegelgracht
Koninklijk Theater Carré
Tropenmuseum
VONDELBUURT
Wilhelminastraat
Rijksmuseum
Weteringschans
Oosterpark
Van Gogh Museum
Heineken Experience
Studio HvA
OLVG, locatie Oost
MUSEUMKWARTIER
OUDE PIJP
DE PIJP
WILLEMSPARK
DUIVELSEILAND
Restaurant Jaspers
SCHINKELBUURT
IJSSELBUURT
Amstelkanaal
Churchill-laan
Hogeschool van
Amsterdam (HvA)
WATERGRAAF
STADIONBUURT
Olympisch Stadion
Amsterdam
Beatrixpark
Restaurant As
Park
Schinkeleilanden
Wagamama
Roosseveltlaan
President Kennedylaan
Sportpark Drieburg
ZUIDAS
Buitenveldert
AMSTERDAM-ZUID
VU medisch centrum
Begraafplaats Zorgvlied
DE OMVAL
Amstel
Amstel Business Park
Arent Janszoon Ernststraat
Nedersticht
Google
Amstelpark
Knooppunt
Amstel

VU VRIJE UNIVERSITEIT AMSTERDAM

The road to a sustainable and bustling VU Campus

Vrije Universiteit Amsterdam has a clear vision and strong set of ambitions in the field of sustainability. To achieve them, the VU grounds are undergoing a complete overhaul to create a new, green campus. The project has three strategic aims, one of which is to increase activity and enhance the quality of life on the university campus, where nearly 30,000 people come daily to work and study. This will encompass the development of a sustainable VU campus, contributing to sustainable area development, improving the natural environment and fostering a blend of residential facilities and urban amenities. So how will these plans take shape over the years ahead? Hello Zuidas talked to Franc van Nunen, director campus development, and Willem Verduyn, real estate manager at VU Corporate Real Estate and Facilities (FCO), who is also the newly appointed board member of the Green Business Club Zuidas.

INCREASING ACCESSIBILITY

Years ago, VU's main building was located in the very heart of Amsterdam. But as the student body got bigger and space got tight, the university traded the city centre for a new campus on De Boelelaan in the 1960s. 'Up until around 2005, many people felt that the university was located on the fringes of the city', Franc says. 'But given the pace of city development since then, we now find ourselves back in the thick of the urban structure. We couldn't be happier, but it also made us realize that we had to think about transitioning from what used to be a relatively closed and largely independent campus to one that's far more integrated with the area and everything that is happening here. We want to make ourselves more visible to the outside world and increase our accessibility, both now and in the future. Lots of people simply pass by the campus, but everyone is welcome to use our facilities or grab a coffee here.'

Franc van Nunen & Willem Verduyn

A SUSTAINABLE CAMPUS

One step on the way to creating a sustainable campus for research and education was the foundation of the Green Office in October of last year. This is a sustainability platform run by and for students and staff who are committed to a greener, more eco-friendly university. 'It has already given rise to a number of fantastic sustainable projects', says Willem. 'For instance, take Join The Pipe, an initiative to install drinking fountains all around the campus, where students can get drinking water and which has led to a drop in purchases of bottled water. Other examples are the creation of a rooftop garden and a recently unveiled charging point on the campus square, where people can charge their electronic devices using solar energy.'

'We feel we're an integral part of Zuidas.'

Water and energy are two key components of the plans for greening the VU campus. VU Amsterdam and VU Medical Center have also jointly signed a water storage and management agreement with Waternet. 'This comes out of our deep-seated awareness that as a major occupant in an area undergoing massive development, we have a serious responsibility to bear', explains Franc. 'Besides, we're also renewing our energy master plan. That involves upgrading the capacity of the existing power station to guarantee a reliable, affordable, sustainable and environmentally friendly on-campus energy supply for the next 15 years.'

Text Romy Lange & Odette van der Veeken

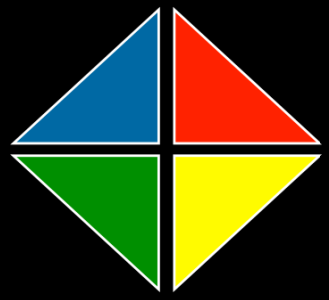
SUSTAINABLE AREA DEVELOPMENT

As well as creating a sustainable campus, VU Amsterdam is also keen to contribute to sustainable area development, as attested by its recent signing of the Sustainability Ambition Statement of the Zuidas Green Business Club.

'Lots of people simply pass by, but everyone is welcome to use our facilities.'

'We're one of 25 organizations to have signed the statement, underscoring our commitment to sustainability efforts not only on campus, but across the entire Zuidas district', explains Willem. 'We feel that we're an integral part of Zuidas and therefore also believe it's important to be an active local player. It's wonderful to be a par of the whole community here. Apart from the social dimensions, our main concerns are mobility and the green quality of the area. Thousands and thousands of visitors come here every day, so it's crucial that transport to and from the area is structured as sustainably as possible. And we are also working actively on water storage. One concern is to prevent flooding during heavy downpours. These are responsibilities that we all share here in Zuidas.'

Research in
Engineering Smart and Sustainable Software: this is what we do…



THE SOFTWARE LAB

Education:
CS Master – Track Software Engineering and Green IT

HOW GREEN IS OUR DIGITAL SOCIETY?

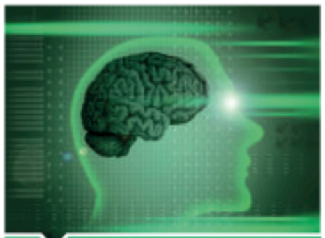
Software-intensive systems support most if not all aspects of modern society. Processing power, data storage, network speed, and energy have become increasingly more powerful and less expensive. However, the energy necessary to keep them on and available is becoming scarce, and is a major global problem that all major nations aim at tackling aggressively. The time has come to build energy-aware software.

PROGRAMME

This extended Master's track allows you to choose either to specialize in energy-aware software engineering, or address the general software engineering competencies while still creating awareness of the implications of software-intensive systems to the environment.
The programme provides both current professionals and future generations with the appropriate skills to build an energy-aware digital society. It provides opportunities for inter-disciplinary assignments and projects addressing societal, business, technical and social aspects of energy-efficient and sustainable software systems. Selected industrial partners will offer innovative case studies and challenging projects.

SELECTED COURSES

Service oriented design: it includes an industry-sponsored project in energy-aware software services (already active since three years, no change).
Software metrics: provides the background on defining and applying software metrics to assess quality requirements of software in general, and energy efficiency and other sustainability-related qualities in the particular case of energy-aware software.
Green Lab: will let students experiment with engineering energy-aware software-intensive systems, measuring, estimating, monitoring their energy consumption, and learning the energy impact of different software engineering practices and design decisions.



"IT SOLUTIONS ARE NOWADAYS MOSTLY EASY TO MIND, BUT THE GREEN ONES ARE HARD TO GET. THINKING GREEN OPENS THE CREATIVE MIND!"

Sarah Laktit, student

MASTER'S TRACK IN
SOFTWARE ENGINEERING AND GREEN IT
2 YEARS
ENROLL BEFORE APRIL 1ST / JUNE 1ST (NL STUDENTS)

MORE INFORMATION

More info about the Green-IT track in the two years Master in Computer Science can be found at: www.vu.nl/computerscience

Questions about the research or courses:
Dr. Patricia Lago (Computer Science),
T +31-(0)20-5987745
E p.lago@vu.nl

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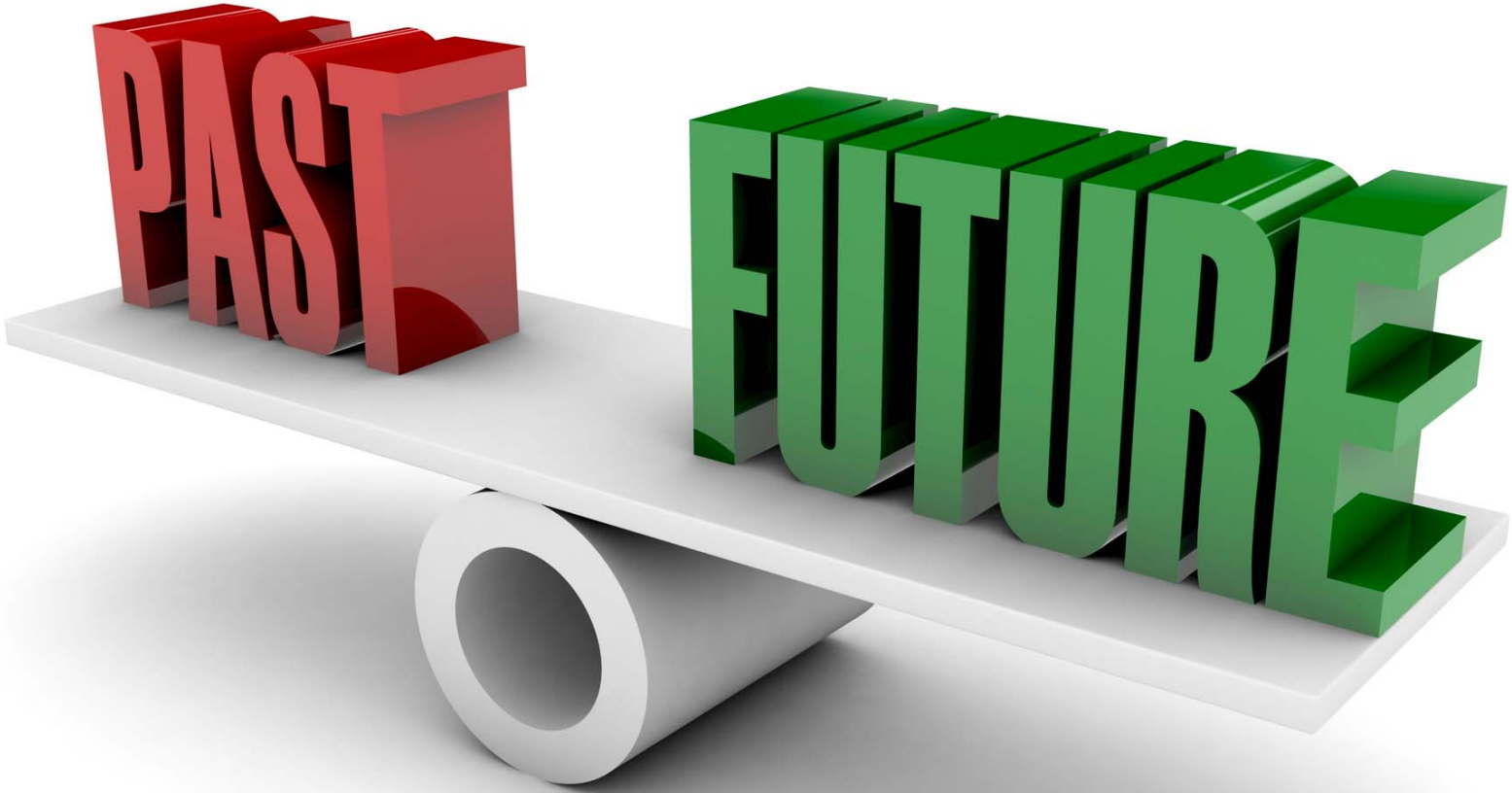
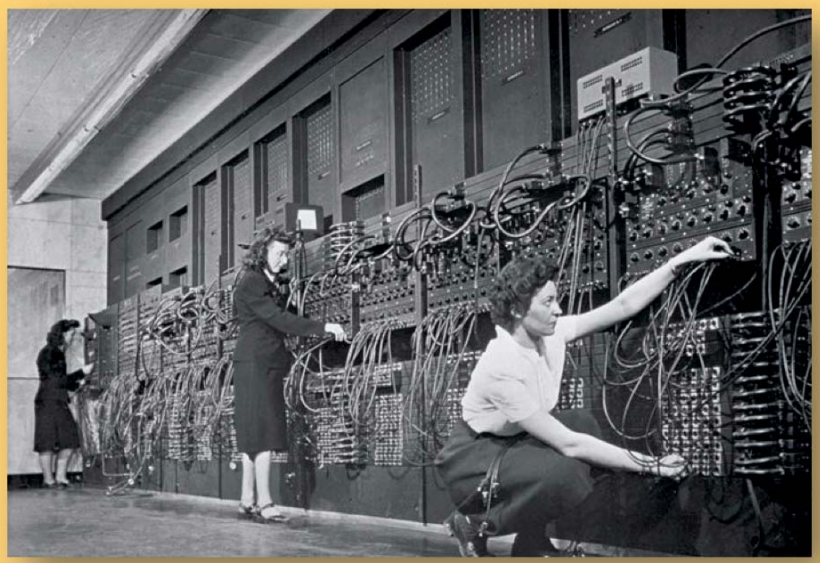


Software follow(ed) unsustainable practices

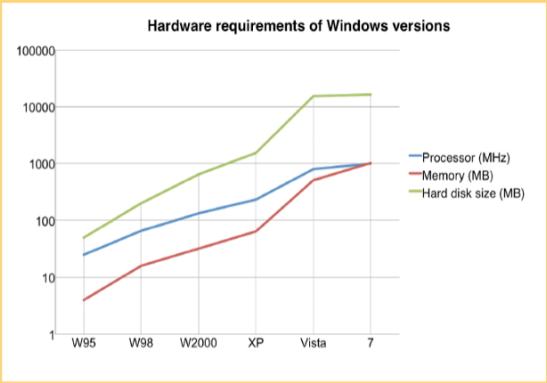
Software is disrupting (future) social and business contexts

The software industry and *un*sustainability



ENIAC Programmers Project (1946)
Photo: Corbis

Steve Jobs unveils the iPhone (2007)
Photo: Wikimedia Commons



Hardware optimizations are negated by software inefficiencies [cf. Wirth' Law]

Potential 87% energy savings with cloud migration of legacy software [Berkeley Labs]

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“Software is eating the world”. Marc Andreessen, 2011
PHOTO: NIGEL PARRY

PATRICIA LAGO ©2016

amazon

© DHL

© TESLA

Disney·PIXAR

"Software is eating the world". Marc Andreessen, 2011

What does “green software” mean?

Energy efficient

Energy aware

Sustainable

© Patricia Lago 2014

What does “green software” mean?

Myth: energy-efficient hardware will solve the issue

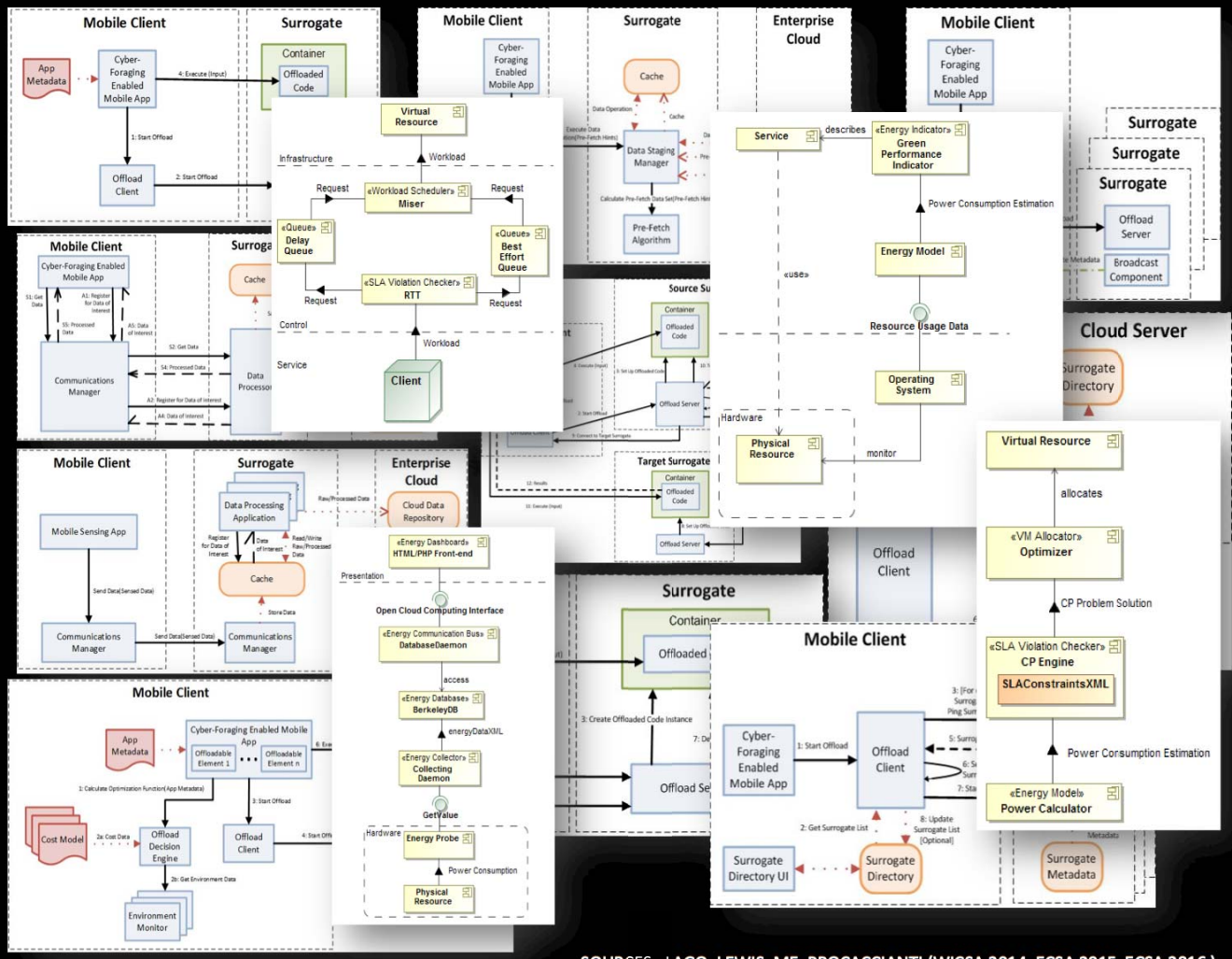
© Patricia Lago 2014

ID	Practice	Description	Category	Environment	Implementation	Energy Consumption Measures	Energy Impact
1	*Use efficient queries*	complex queries can be performed to increase the responsiveness of the application at the expense of energy efficiency. Can be useful to avoid unnecessary "ORDER BY" or to use indexes.	Database	SEFLab	MySQL Server + WIkipedia DB, measure response time during query	System level, resource level incl. usage ratio, software execution measures (response time, number of request/query served)	-25% energy consumption
2	*Put application to sleep*	in order to save energy the application can be put in sleep mode. An event, a signal, or an interrupt can resume the application.	Coding	SEFLab	Apache WebServer		-8,5% energy consumption

[S2 Green Software Wiki, wiki.cs.vu.nl/green_software]

[Procaccianti, Fernandez, Lago, Empirical evaluation of two best practices for energy-efficient software development, Journal of Systems and Software, 117:185-198, 2016]

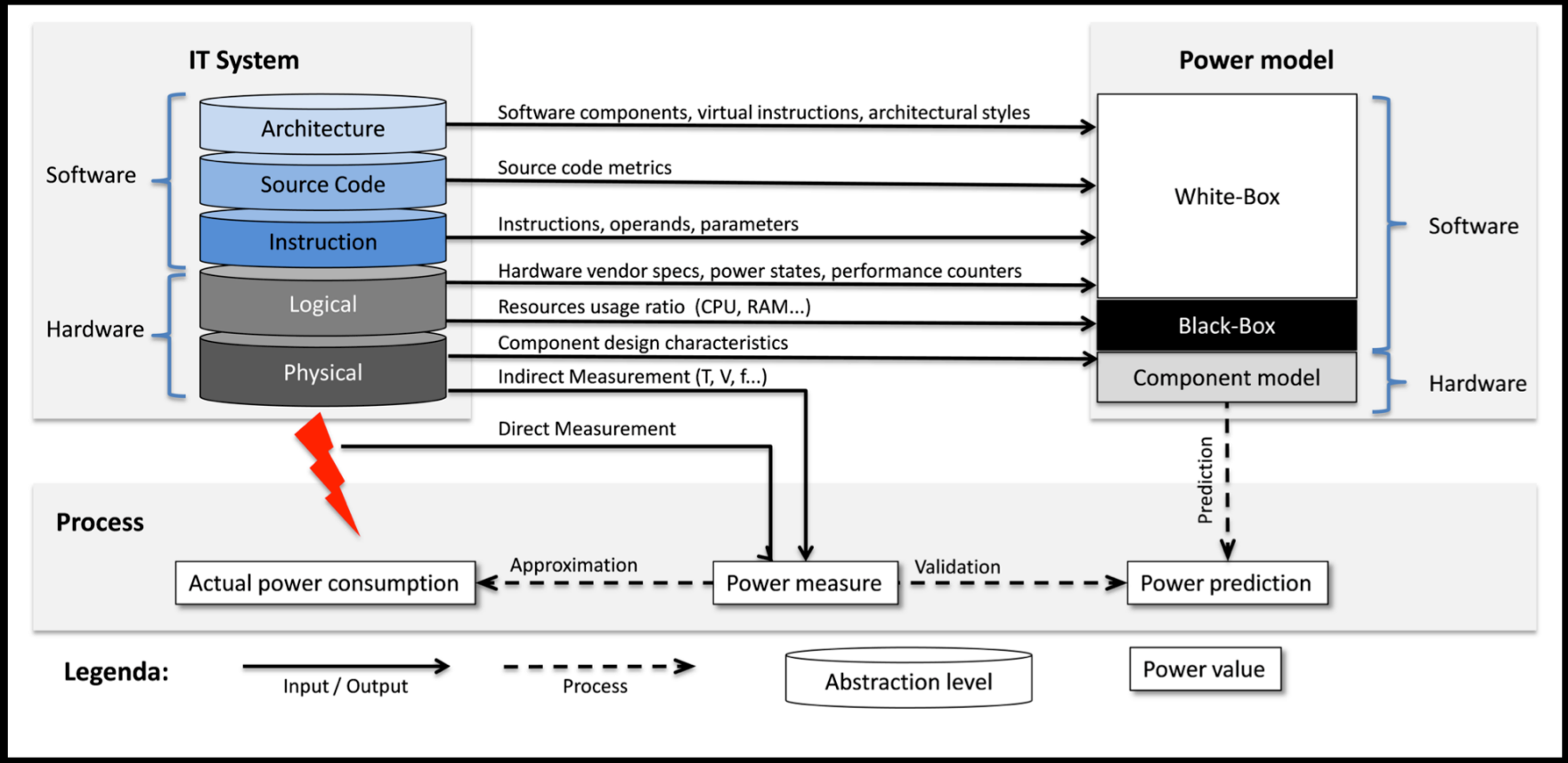
Energy-efficient software: By implementation



SOURCES: LAGO, LEWIS, ME, PROCACCIANTI (WICSA 2014. ECSA 2015, ECSA 2016)

Energy-efficient software: By design

REUSABLE DESIGN PATTERNS AND ARCHITECTURAL TACTICS

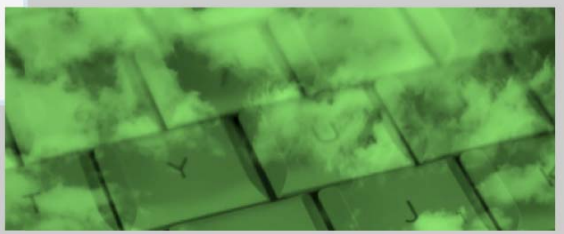


Need 4 research:
Too many variables, too much “noise”

EFFICIENT DATABASE QUERIES
-25% energy consumption

OPTIMIZED DATA MANAGEMENT
+70% performance

FLEXIBLE COMPUTATION OFFLOAD
-40% power consumption



SMART USE OF WEB RESOURCES
-8,5% energy consumption

WEBSITE CONTENT DELIVERY
-45% energy consumption

SOFTWARE REFACTORING
-50% energy consumption
-20% power consumption

Some numbers: true or false?

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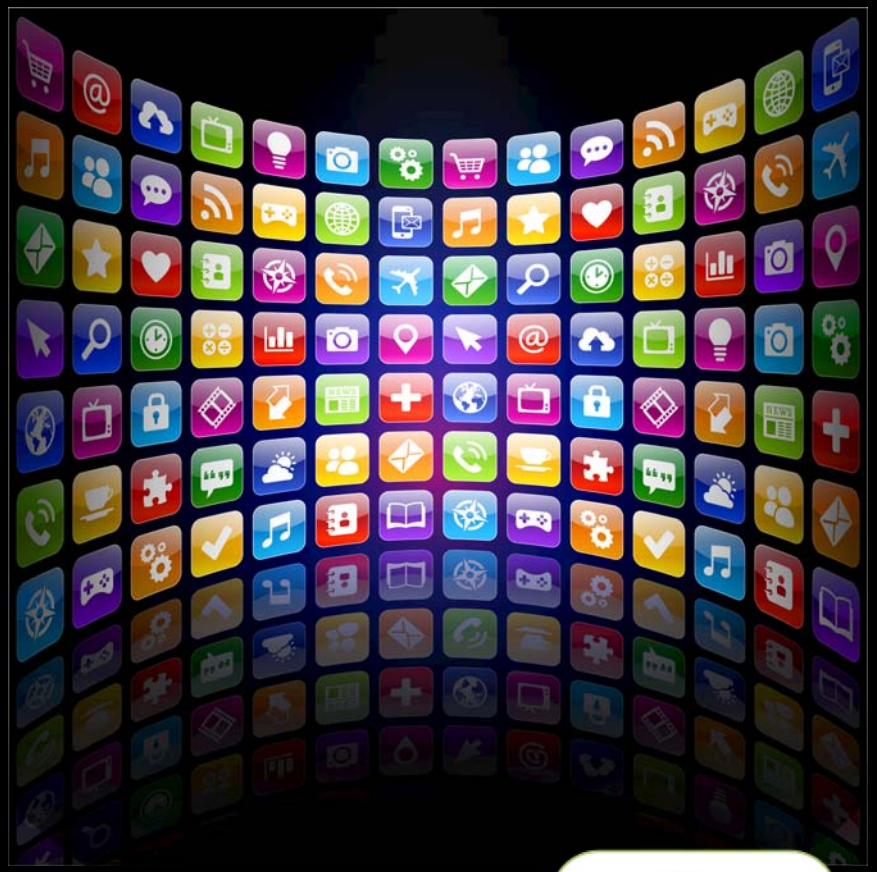
Mission impossible II (2000), the motion picture

Resource scarce environment

Smart home

Energy-aware (smart) software:
Cyber-foraging optimizes functionality by resource discovery



Need 4 research:
A green label for software, too

GREEN LAB – VRIJE UNIVERSITEIT AMSTERDAM

SIGNED, SEALED… DELIVERED?
Behind Certifications and Beyond Labels

SustainAbility

Deconstructing the model

STANDARDS set requirements to follow often taking a consensus-based approach

CERTIFICATION provides third-party assurance of conformity against a standard

FSC

LABELS are on-pack marks or seals that indicate conformance with the standard

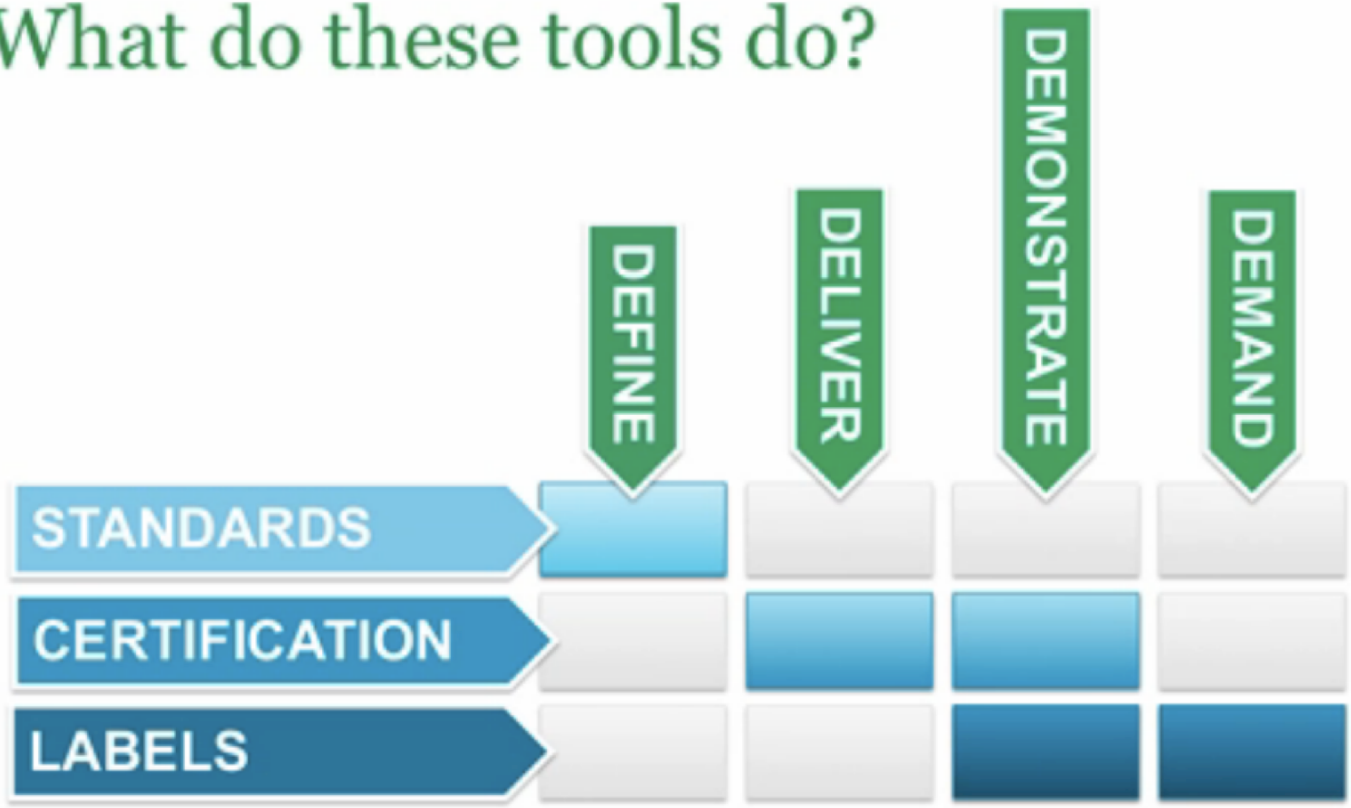
What should a *green label* really do?

SIGNED, SEALED… DELIVERED?

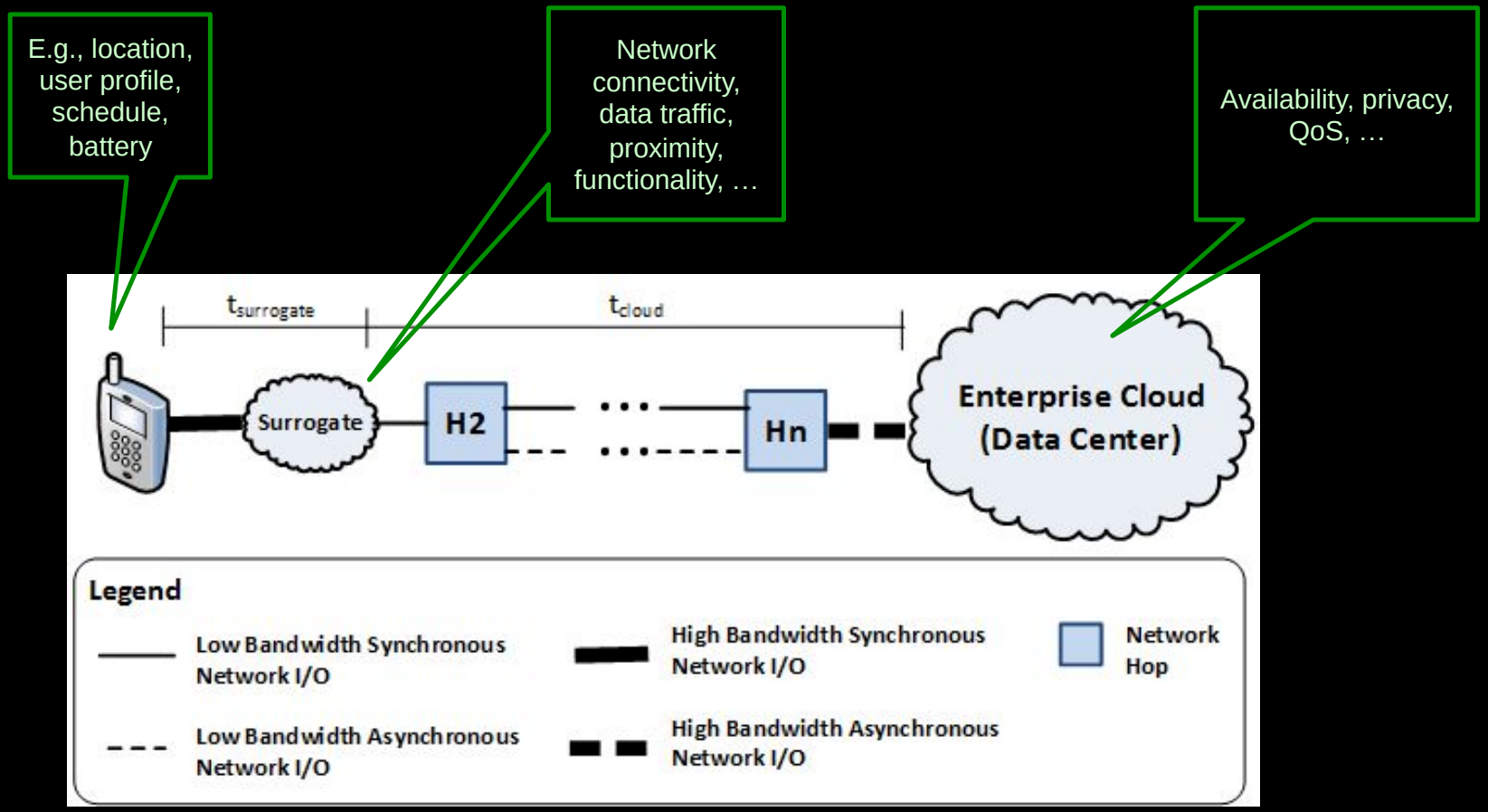
Behind Certifications and Beyond Labels

SustainAbility

What do these tools do?

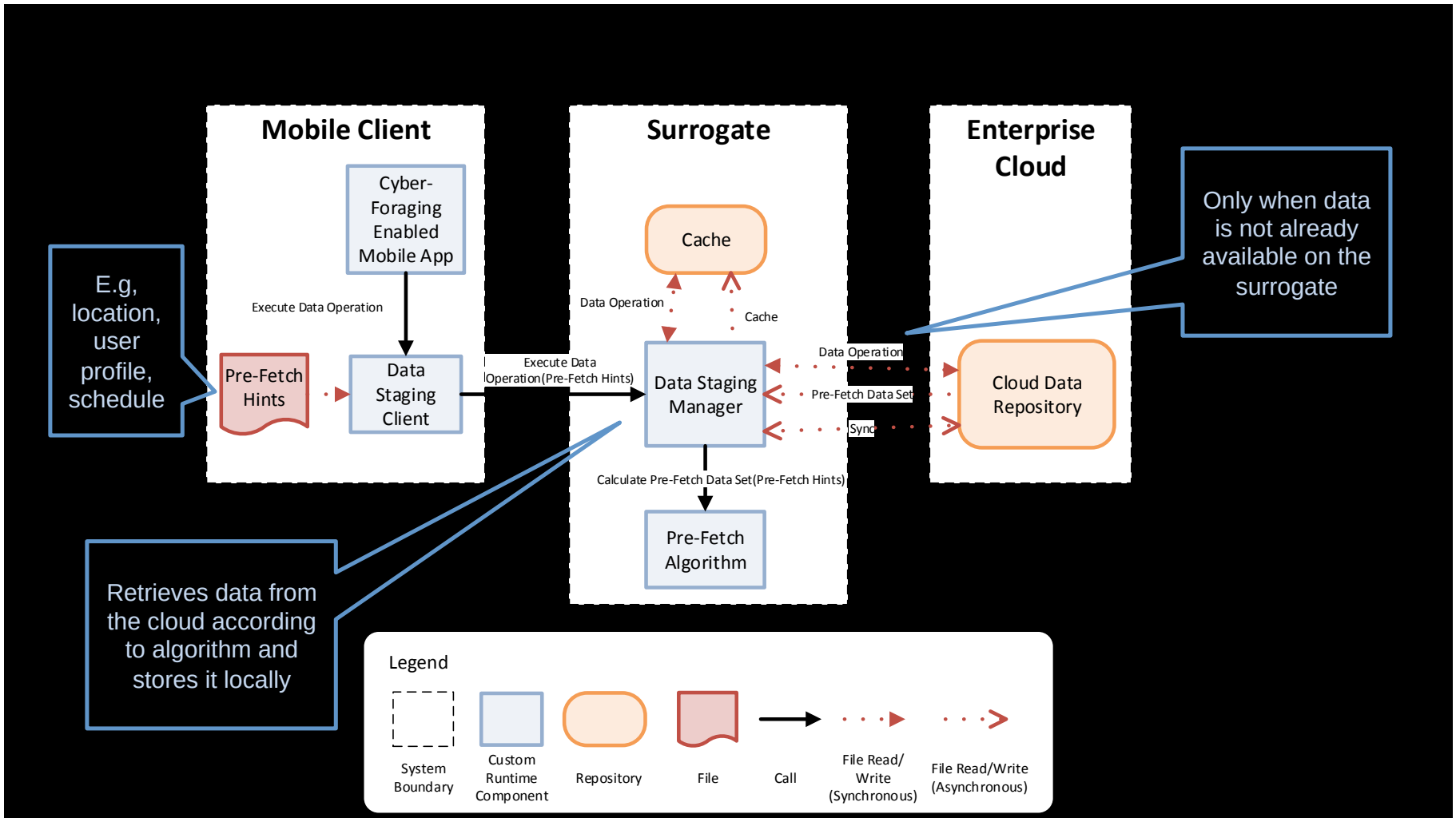


What should a green label *mean* for software?



G. Lewis & P. Lago, "Characterization of Cyber-Foraging Usage Contexts", In Software Architecture, Springer LNCS (2015)

(Energy-aware) smart software:
Cyber-foraging optimizes functionality by resource discovery



G. Lewis & P. Lago, "Characterization of Cyber-Foraging Usage Contexts", In Software Architecture, Springer LNCS (2015)

(Energy-aware) smart software: Cyber-foraging software tactics make the cloud smarter

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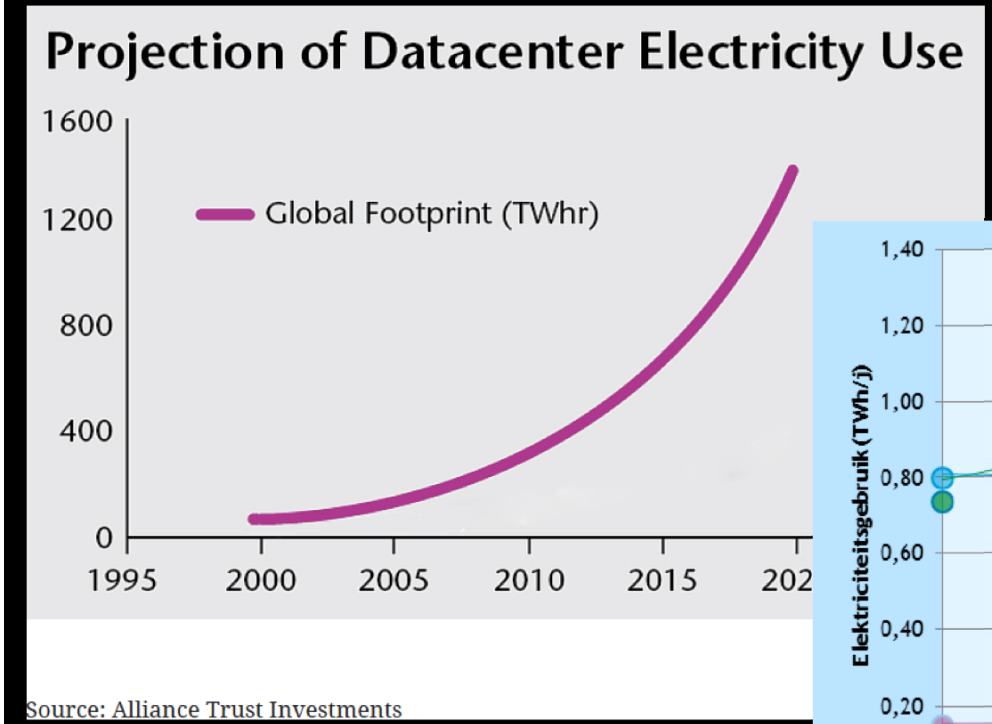
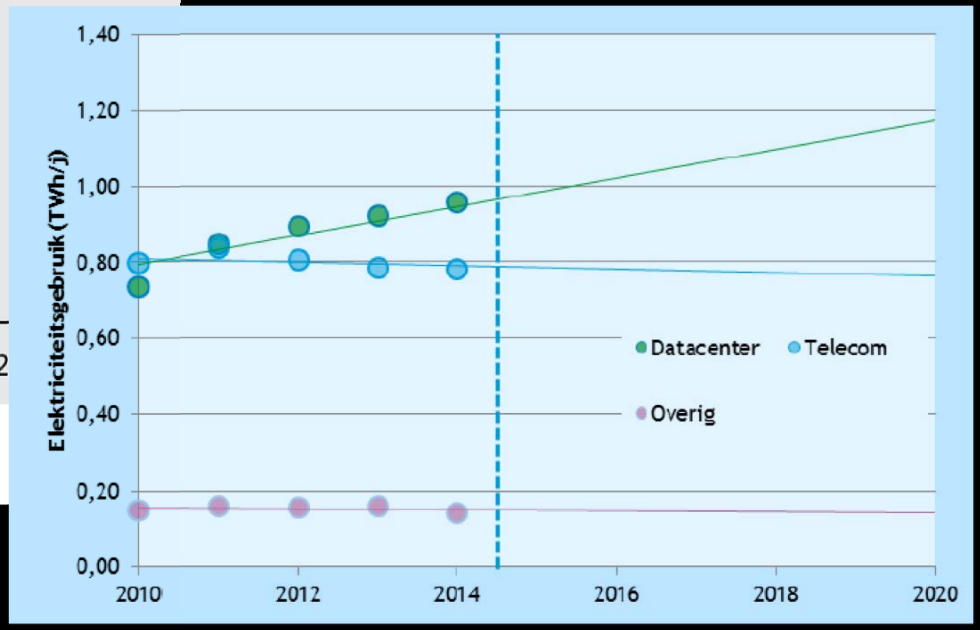
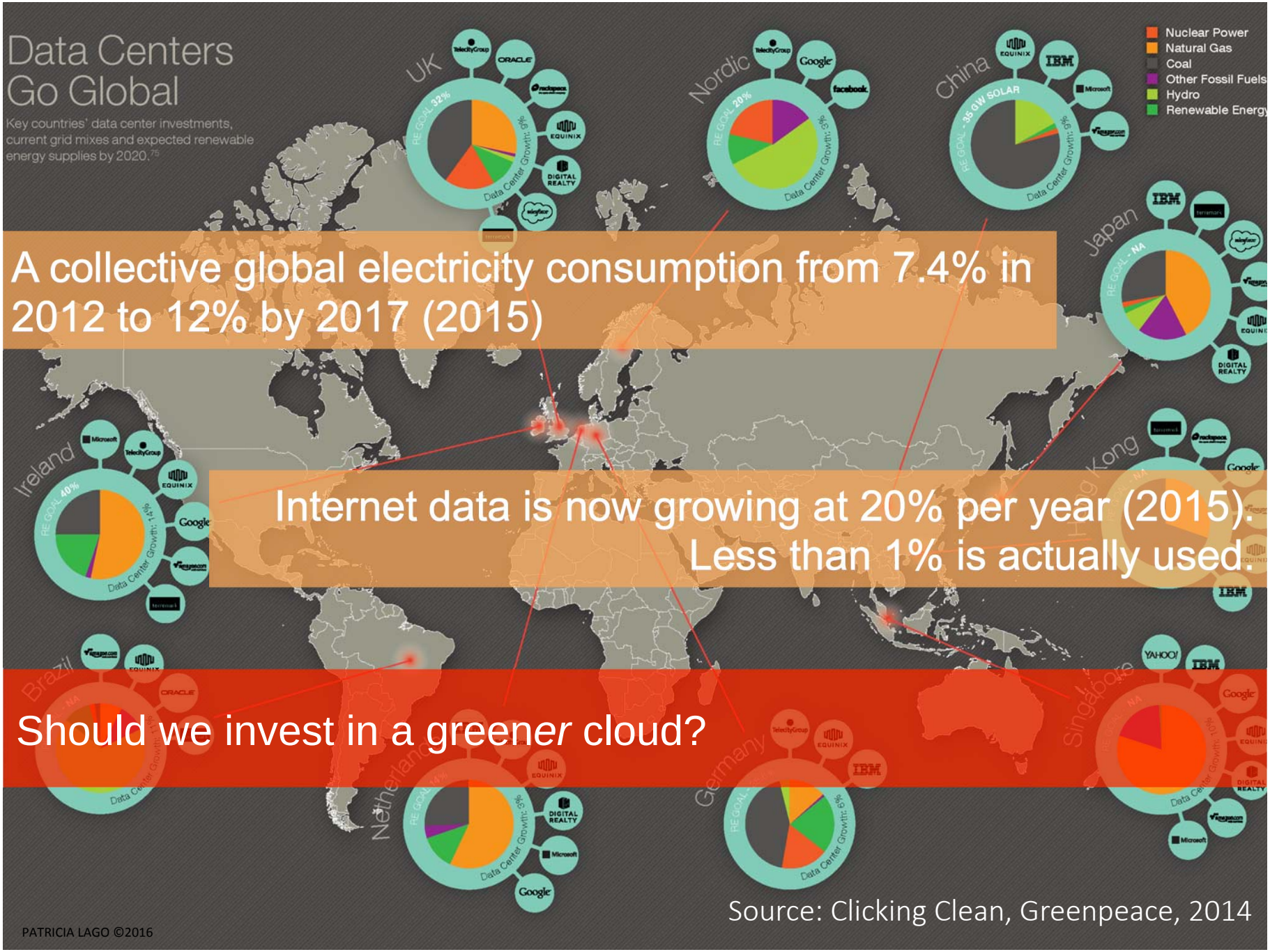




SOURCE: Trends ICT en Energie 2013-2030 (2016)

If software gets smarter,
should we (still) invest in a greener cloud?



Source: Clicking Clean, Greenpeace, 2014

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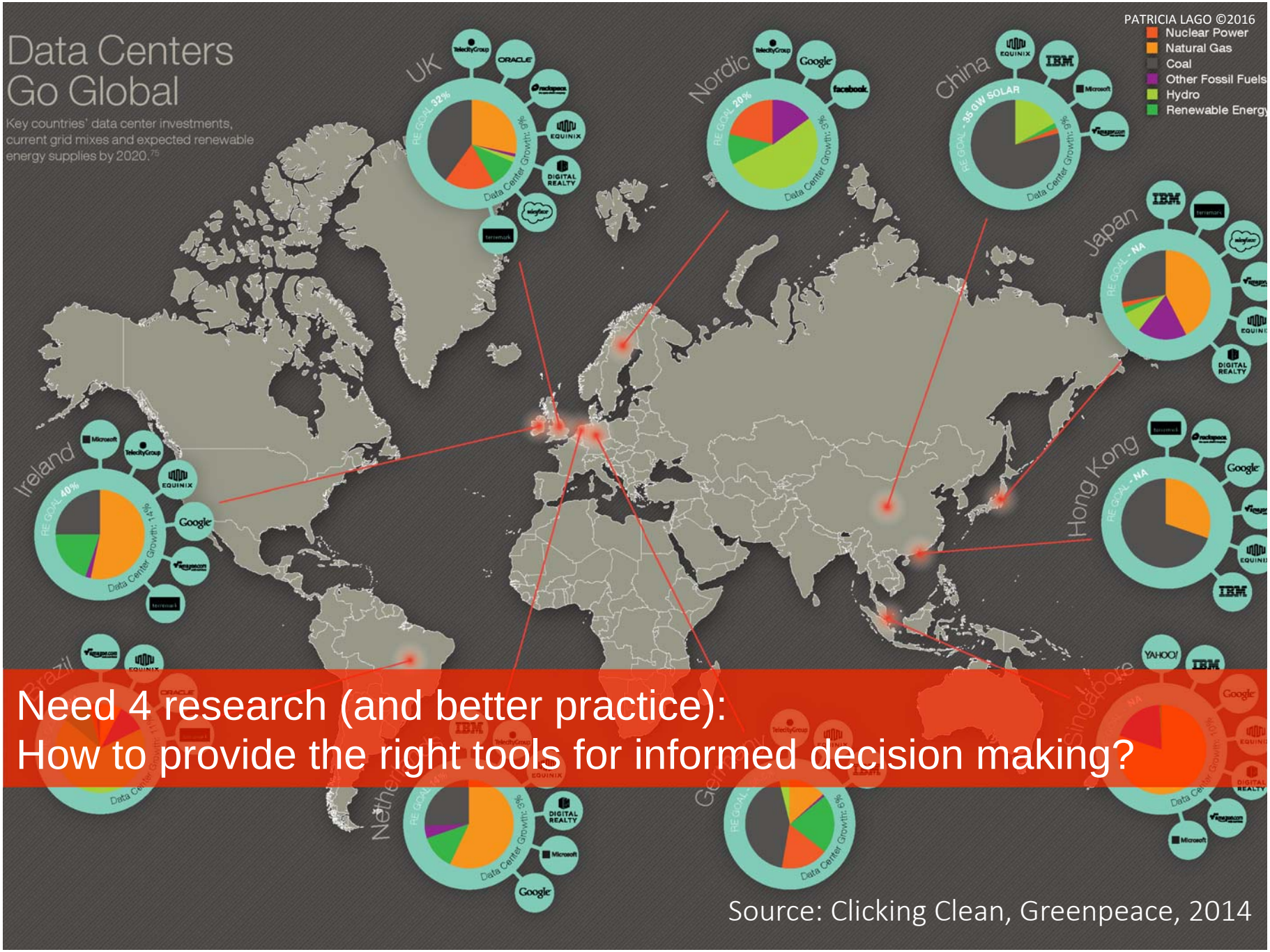
Data Centers Go Global
Key countries' data center investments, current grid mixes and expected renewable energy supplies by 2020.[75]
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Nuclear Power
Natural Gas
Coal
Other Fossil Fuels
Hydro
Renewable Energy
UK
Nordic
China
Japan
Ireland
Hong Kong
Need 4 research (and better practice):
How to provide the right tools for informed decision making?
Source: Clicking Clean, Greenpeace, 2014

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IEBlog

MSDN Blogs > IEBlog > Browser Power Consumption—Leading the Industry with Internet Explorer 9

Browser Power Consumption—Leading the Industry with Internet Explorer 9

Published Monday, March 28, 2011 8:10 PM

146 comments

Power consumption is an important consideration in building a modern browser and one objective of Internet Explorer 9 is to responsibly lead the industry in power requirements. The more efficiently a browser uses power the longer the battery will last

Comparison study between IE9, Chrome, Firefox, Opera, Safari

Guess who won?

What software product should we buy?

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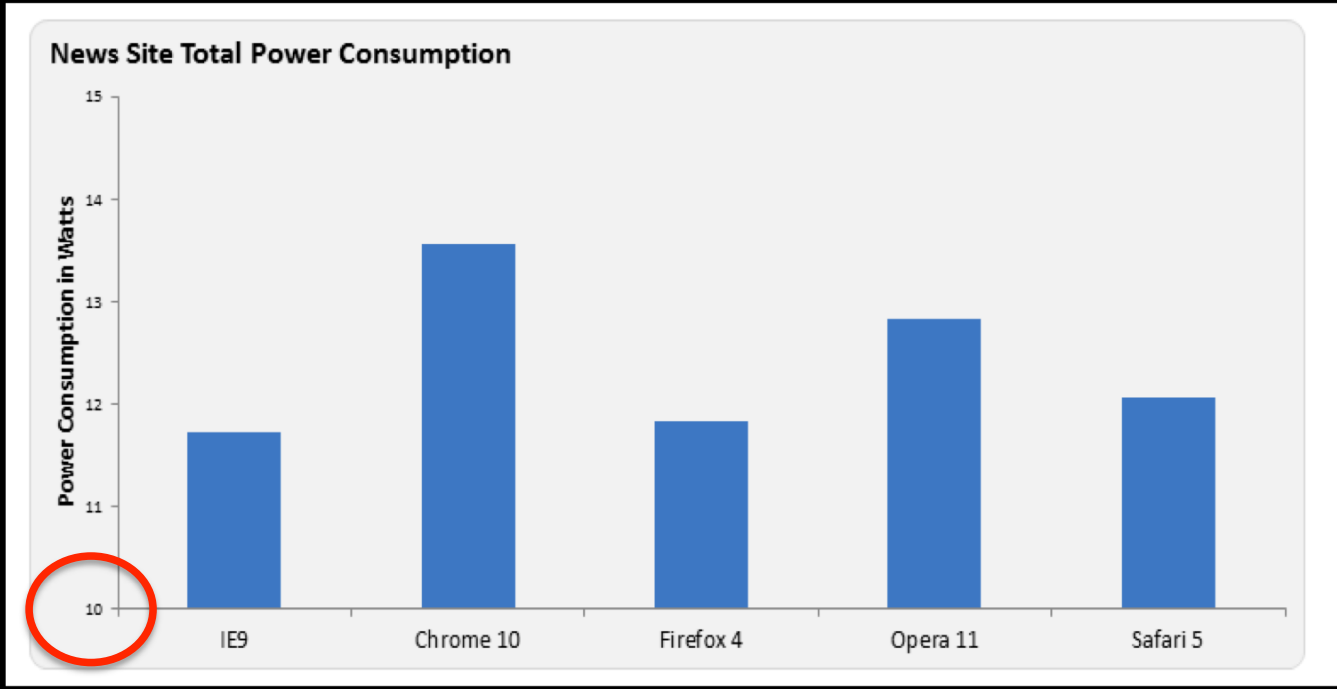
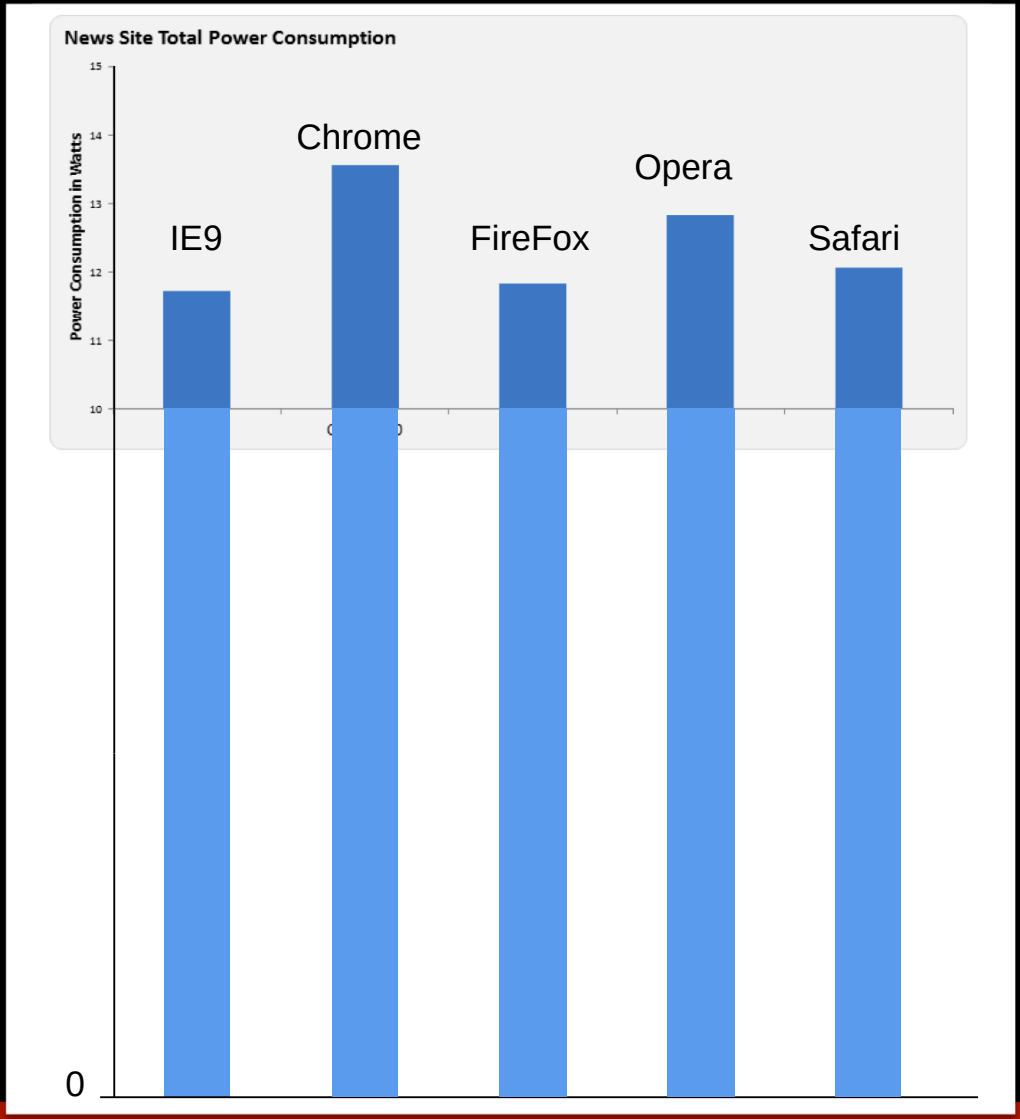
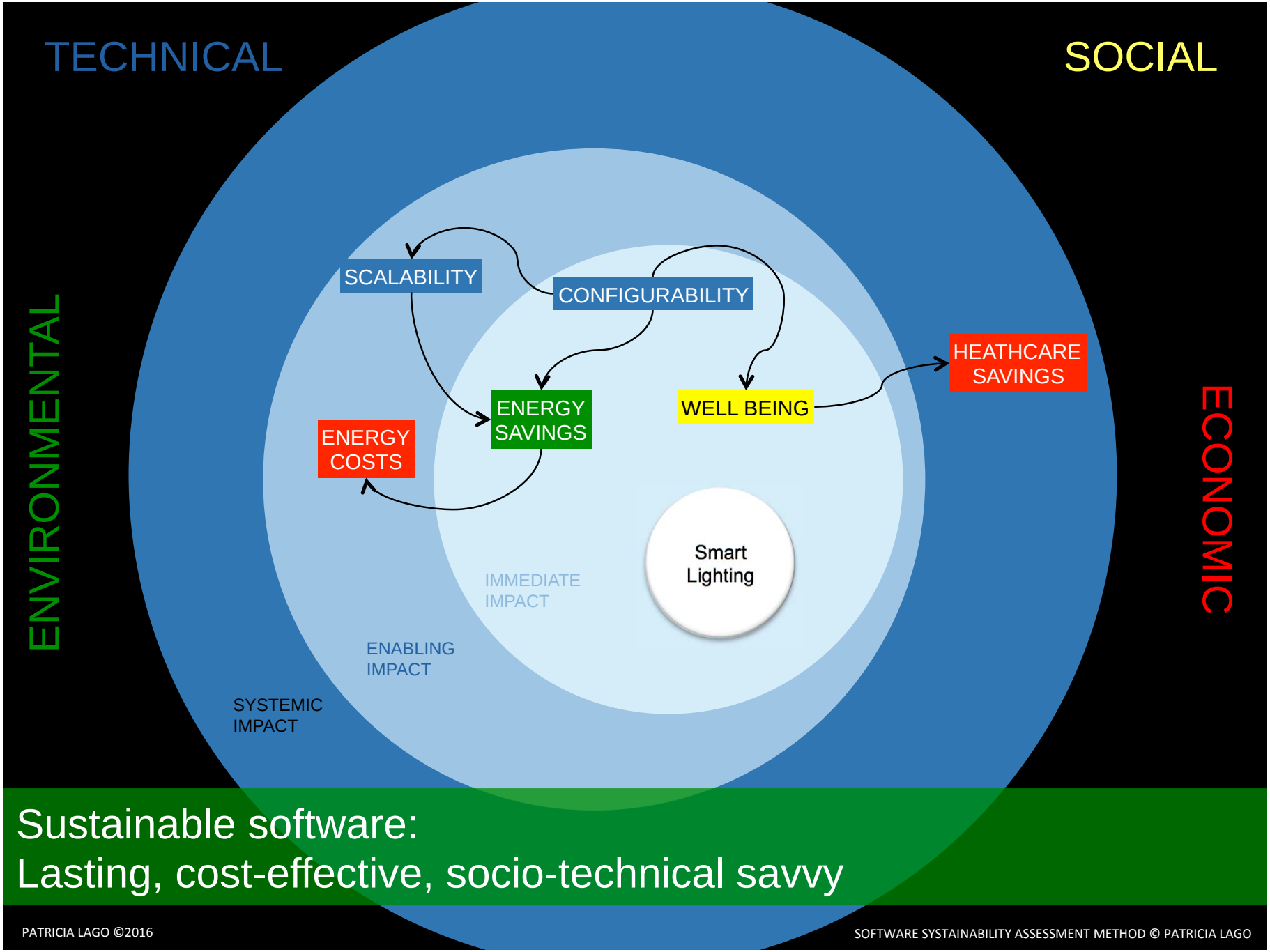


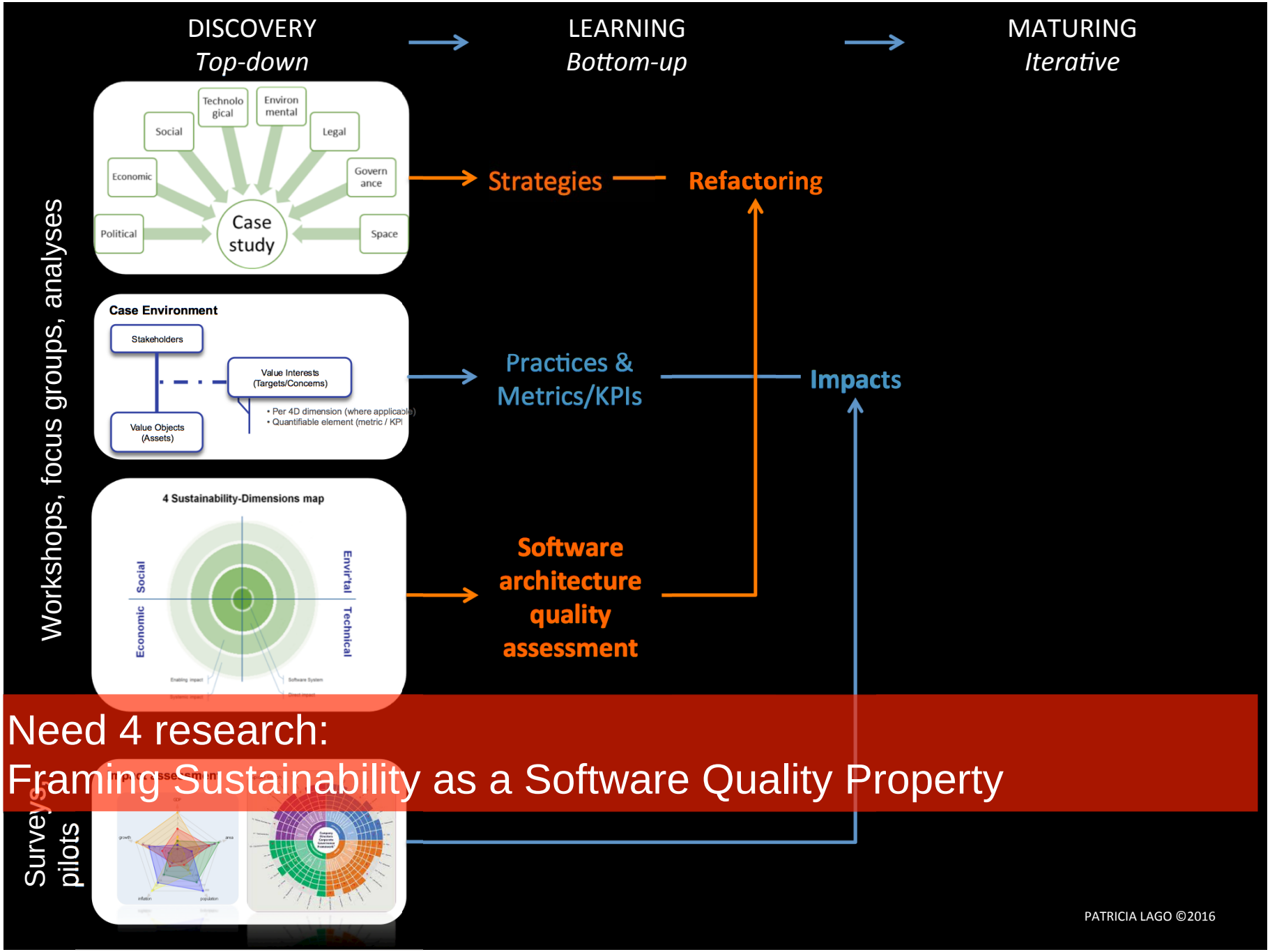
What software product should we buy?

PATRICIA LAGO ©2016



Need 4 research (and better practice): (Truthful) visualizations


TECHNICAL
SOCIAL
ENVIRONMENTAL
ECONOMIC
SCALABILITY
CONFIGURABILITY
ENERGY SAVINGS
ENERGY COSTS
WELL BEING
HEATHCARE SAVINGS
Smart Lighting
IMMEDIATE IMPACT
ENABLING IMPACT
SYSTEMIC IMPACT
Sustainable software:
Lasting, cost-effective, socio-technical savvy
PATRICIA LAGO ©2016
SOFTWARE SYSTAINABILITY ASSESSMENT METHOD © PATRICIA LAGO


DISCOVERY
Top-down
LEARNING
Bottom-up
MATURING
Iterative
Workshops, focus groups, analyses
Surveys, pilots
Technological
Environmental
Social
Legal
Economic
Governance
Political
Space
Case study
Strategies
Refactoring
Case Environment
Stakeholders
Value Interests (Targets/Concerns)
Value Objects (Assets)
• Per 4D dimension (where applicable)
• Quantifiable element (metric / KPI
Practices & Metrics/KPIs
Impacts
4 Sustainability-Dimensions map
Social
Envir'tal
Economic
Technical
Software architecture quality assessment
Need 4 research:
Framing Sustainability as a Software Quality Property
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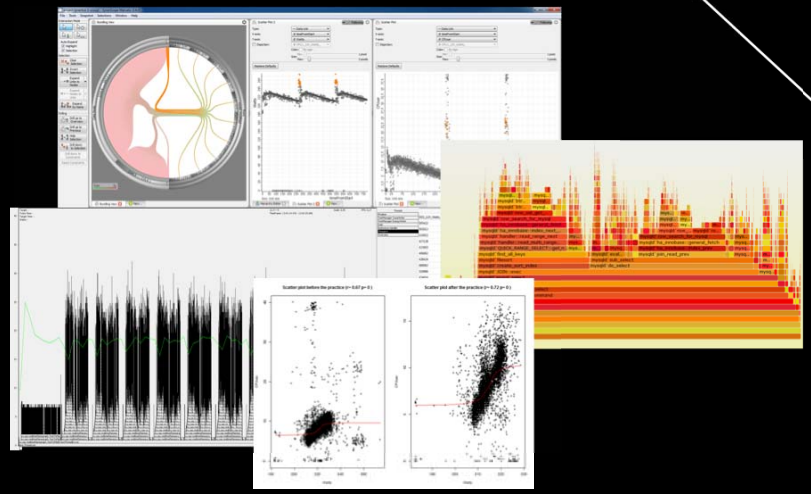
Smart resource utilization

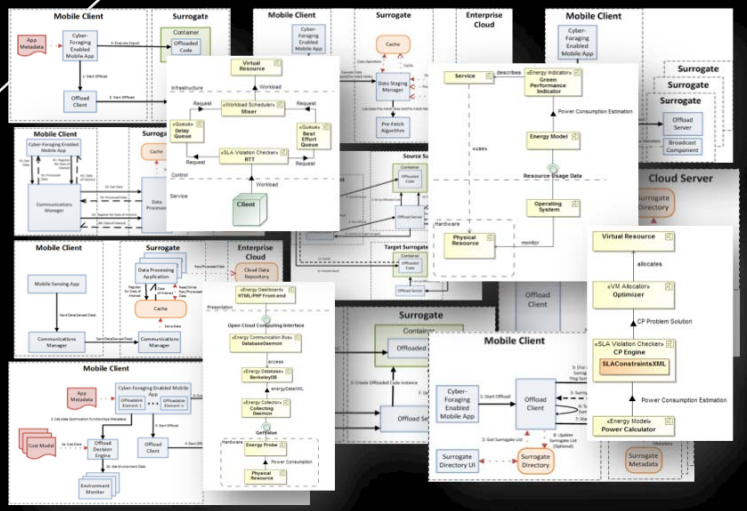
Embody sustainability in SE

IMAGE: ANONYMOUS



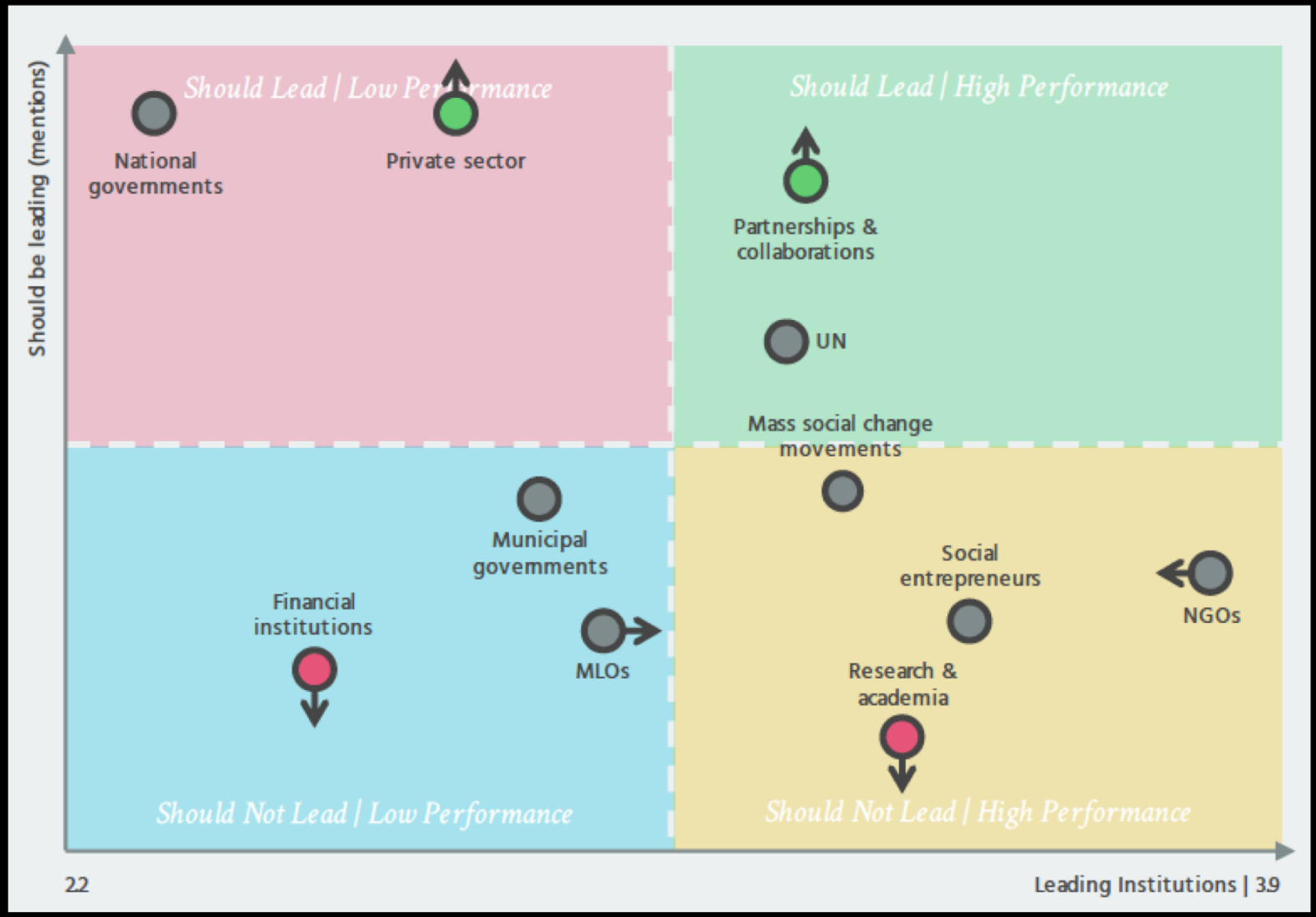
SOURCES: S2GROUP (2014) & ADS project BIG DATA 4 GREEN SOFTWARE (2015)

Measure and visualize



SOURCES: LAGO, LEWIS, PROCACCIANTI (WICSA 2014. ECSA 2015)

Informed design decision making



In your opinion, who should lead the sustainable development agenda over the next 20 years?

Thank you

Credits: slides, ideas and results are a collective effort with my bright and energetic colleagues in the S2 Group @Vrije Universiteit Amsterdam
www.s2group.cs.vu.nl

@patricia_lago

What specific companies do you think are leaders in integrating sustainability into their business strategy?