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Short communication

Reshaping the education of energy managers

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ABSTRACT

Newly educated Energy managers will play a key role in the unfolding global transition to renewable energy and sustainability. We describe a new approach to energy management education via a cross-disciplinary postgraduate course ('*Lean and Green*') targeting management, economy, physical science and engineering graduates with the objective to shape Energy managers working in the top management of service and manufacturing organizations to effectively achieve higher levels of energy efficiency and renewable energy penetration, while improving the levels of quality, work and service.

1. Background

The transition to energy efficient societies in which, furthermore, energy is massively generated from renewable energy sources, requires a better, multidisciplinary education of engineers, managers and policy makers [1]. For example, a clear gap between the solutions available for integrating energy efficiency in industrial companies and their actual implementation was found in Europe in 2001 [2], when it was concluded that effective energy management requires to consider energy efficiency as a strategic factor alongside with technical measures.

In 2010, a concomitant shortage of managers with energy efficiency experience, as well as of energy efficiency engineers was found by scholars in the US [3]. The team concluded warning Universities planning new energy efficiency-related programs that "while many PhDs in other disciplines stay in academia, most of the PhDs with energy efficiency expertise find jobs in industry, due to high demand and excellent compensation' [3]. Several other examples testify to the well known, but ongoing, 'energy-efficiency gap' [4].

Improving energy efficiency and promoting the widespread use of renewable energy directly lowers the energy cost faced by an organization, by making its use more affordable [5]. Yet, until the oil (and thus energy) supply has been available at low cost, namely until the end of the 1990s, the energy management profession has suffered the low status identified in several studies as one of the main barriers to energy efficiency [6].

When, in the subsequent decade, the price of oil surged from around $12/barrel in 1998 to $147/barrel in July 2008 [7], the profession of Energy manager suddenly acquired strategic relevance, first at energy-intensive organizations, and then also at service organizations including cities, government offices, hospitals, and large buildings.

That of today's Energy manager has become a very complex figure with updated knowledge and skills crossing many fields beyond energy, including people management, environmental science and technology, finance, personal and enterprise communication, information and communication technologies, and even teaching skills.

The education of today's Energy managers needs to be widened accordingly, for two main reasons. On one hand, the concomitant accelerated development in digital, energy efficiency and renewable energy technologies requires to widen and update the curricula. On the other, and perhaps more fundamentally, there is the need to integrate the study of energy efficiency and renewable energy along with that of management so as to make energy management education consistent with the managerial role of today's Energy manager.

After reviewing current educational practices in Europe and in the US, in this study we identify the requirements of a postgraduate course ('Lean and Green') targeting physical science, engineering and management graduates aimed at shaping managers capable to effectively manage energy at industrial and service organizations.

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Table 1
List of the subjects for the CEM exam.

Topics	Percent of Exam
Codes and Standards	4–6%
Energy Accounting and Economics	11–14%
Energy Audits and Instrumentation	11–15%
Electrical Systems	5–7%
Heating, Ventilating, and Air Conditioning Systems	5–7%
Motors and Drives	5–6%
Industrial Systems	4–6%
Building Envelope	4–5%
Combined Heat and Power Systems and Renewable Energy	4–5%
Fuel Supply and Pricing	4–5%
Building Automation and Control Systems	4–6&
High Performance Buildings	4–5%
Thermal Energy Storage Systems	3–4%
Lighting Systems	5–7%
Boiler and Steam Systems	4–6%
Maintenance and Commissioning	4–6%
Energy Savings Performance Contracting and Measurement and Verification	4–5%

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2. Energy manager training

The first educational programs for Energy managers go back to 1981 when the based Association of Energy Engineers (AEE) created in the US the Certified Energy Manager (CEM) credential as a measure of professional accomplishment within the energy management field [8]. Today the CEM status is widely recognized as an important standard for qualifying energy professionals, and the AEE reunites over 17,000 professionals from 90 countries.

Between 2011 and 2013, the three reference books used at courses propedeutic to grant the CEM status, namely *Energy Management Handbook* [9], *Handbook of Energy Engineering* [10], and *Guide to Energy Management* [11], had reached the eighth or the seventh edition.

In general, the educational requirements for Energy managers are broad and take into account the range of educational degrees and years of experience candidates may have. Students of CEM courses have a combination of education and experience. They usually have Bachelor's degrees in engineering, physical sciences, architecture, or have business backgrounds as facility and information and communication technology managers.

It is relevant, for the purpose of this study, to compare the typical curricula of energy management courses granting the credential of certified Energy manager in Europe and in the US. In America, students are examined with respect to 17 mandatory topics (Table 1) [12].

In Europe, EUREM ('European EnergyManager') is a standardized training course offered in 30 countries consisting of 160 units (45 min) of classroom training held by experienced trainers with a professional background, followed by a final project work (80 units) [13]. The training contents include engineering and management topics (Table 2). The basic knowledge (and current role) requirements for participants to the EUREM course are displayed in Table 3. Noticeably, they include 'Access to top management, be able to introduce meaningful suggestions'.

In the US, if the CEM candidate has a 4-year degree in technology, environmental science, physics, chemistry or earth science then a minimum of 4 years of experience in energy engineering or energy management is required to apply. Viceversa, if the candidate has a 4-year degree in business, management or related field, then she/he should have a mimimum of 5 years of experience in energy engineering or energy management

Table 2
Training contents of the EU EUREM course.

Engineering	Management
Basics of energy engineering	Energy management systems
Building physics	Economic calculation
Energy-conscious building and renovation	Energy contracting
Heating engineering/geothermal energy	Project management
Process heat	Energy purchasing, energy trade
Ventilation | Air conditioning	Energy legislation – rules and standards
Refrigeration engineering	Climate protection management – emissions trading
Compressed air	
Lighting	
Electrical drives	
Green-IT	
Process and load management	
Monitoring and control systems	
Cogeneration	
Solar technology	
Energy from biomass	

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Table 3
Qualification profile of EUREM training participants.

Basic knowledge of energy technology
Established function on management level
Decision competences
Good knowledge of the production and energy relevant processes
Access to top management, be able to introduce meaningful suggestions
Experience in operational energy concept
EDP knowledge (Windows, Word, Excel)
Intensive professional experience

Reproduced from Ref. [13], with kind permission.

After completing the course both in the case of the CEM or EUREM programs, participants should have acquired three main skills, namely *i*) analyzing the energy situation, *ii*) develop a technically sound energy savings roadmap, and *iii*) sell it to top management.

The EUREM certificate is awarded to participants who have attended at least 80% of the training sessions, after having successfully passed a written exam and completed an 'energy concept'. The written exam addresses five subject area (3 for efficiency technologies, one for management, and one for renewable energy).

The 'energy concept' is a unique feature of the EUREM course through which every participant presents in 7–10 min to an evaluation group the outcomes of her/his analysis of the energy situation of the candidate's work environment, illustrating in 5–10 slides how to improve it. The idea is trying to sell the investment proposal to top management. The overall mark is the mean of the values got in the written test and in the energy concept (50:50 ratio).

In fifteen years (2000–2015), the number of certified European EnergyManagers has reached 4500. By early 2016, another 500 EUREM candidates were enrolled in courses outside Europe, as the EUREM training expanded to include India, Chile, China, Mexico and other countries.

3. Energy manager: a young and rapidly changing profession

That of Energy manager is a relatively young job. For example, the US job market surveyed in 2015 by the AEE, reveals that 53% of the Energy managers had between 0 and 10 years of energy man-

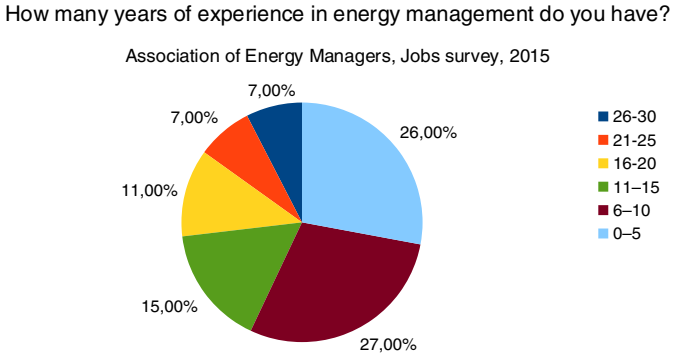

Fig. 1. Years of experience of US Energy managers.

agement experience, with only 14% having more than 21 years of experience (Fig. 1) [14].

Today's Energy managers are important management professionals, with typical USD or EUR 100,000 annual salary, working in large and medium sized organizations helping to keep industries and offices competitive by making their organization more efficient, less wasteful and increasingly reliant on renewable energy. Their role is no longer limited to metering and critically examining the energy flow through a system [15].

The Energy manager monitors and analyzes energy and resource consumption so as to develop, get approved and implement consistent energy efficiency projects [16]. The skills required to accomplish these tasks clearly identify a managerial activity, one with a significant technical background, but still a management endeveaour carried out in office, at job sites to oversee project implementation and even in the classroom to train and educate colleague managers in top and intermediate management ladders.

4. A course built around customer demand

Following the systems thinking approach widely explored by Seddon et al. [17] we have designed a course that delivers education based on a deeper understanding of what matters to future Energy managers, and to their forthcoming customers: the Chief operating officers at both service and manufacturing organizations.

In brief, customers of energy efficiency services across the world demand efficient, reliable solutions for gaining significant energy savings, reduce costs, and maintan or even increase production levels, while being protected against volatile energy prices. Energy efficiency, in other words, has to do with 'doing more with less' [18], and not simplistically with energy savings, such as in the case when people are asked to switch off the light or unplug their computers, and then claim to have 'done something to improve the world' [19].

When deciding about energy efficiency investment, top managers are interested in the payback period, increased productivity and additional benefits like lower maintenance cost [20]. Consequently, Energy managers are not interested in rethorics of today's energy and environment discourse ('the gospel of efficiency', to say it with Herring) [5], but have a keen interest in learning how to get projects approved by top management, while interacting in a positive fashion with workers across the whole organization.

Indeed, these are precisely the skills identified by US energy managers recently surveyed to understand the most challenging tasks about their job (Table 4).

Furthermore, Energy manager professionals have a great interest in learning which economically viable, advanced solutions chosose to actually do energy efficiency; and they want to access this knowledge in a contextualized framework ('in engineering education the technical part is the 'text' and the historical, social, political, etc. elements are the con-text") [21], in which technical content is critically presented so as to understand not only the strengths but also the limitations of the new knowledge conveyed along with said education [22].

Table 4
What is most challenging about your job?

Answer Options	Response Percent
Getting projects approved by top management	36.3%
People management skills	14.3%
Approval of new and innovative energy management	27.4%
Other	22.0%

Reproduced from Ref. [14], with kind permission.

Table 5
'Lean and Green': training contents.

Engineering	Management
Energy and Energy efficiency	Systems thinking for effective management
Building physics	Work flow mapping
Energy-conscious building and renovation	Energy contracting
Energy efficient heating	Effective communication of energy efficiency
Process heat	Energy purchasing, energy trade
Air conditioning	Energy legislation and standards
Efficient refrigeration	Energy management at industrial companies
IP-enabled solutions for energy efficiency	Energy management in service organizations
LED Lighting	Field trips to service and manufacturing facilities
Electrical drives	
Green-IT	
Process and load management	
Monitoring and control systems	
Cogeneration	
Solar energy technologies	
Distributed energy generation	

5. 'Lean and green'

Energy management and energy studies need social science [23]. Dubbed 'Lean and Green', the present new course on energy management teaches the technical solutions and the managerial approach to effectively achieve ever higher levels of energy (and resource) efficiency and renewable energy adoption in organizations. This, we argue herein, requires tomorrow's Energy managers to acquire the crucial ability of management, namely 'integration and decision making across various functional areas, groups of people, and circumstances' [24]. Furthermore, said newly educated Energy managers will learn that is the economies of flow, rather than economies of scale, that maximizes value and minimizes waste [25].

Students of course are presented with a body of technical content, which includes energy science and engineering, energy policy, environmental aspects of energy sources and utilization, smart (IP-enabled) control technologies, LED lighting, value mapping, energy contracting, effective communication of energy efficiency, and much more (Table 5).

Participants are taught the central relevance of the information and communication technologies in today's practice of energy efficiency, as the enabler of intelligent, flexible solutions capable to maximize savings and performance. For instance, they are shown

Fig. 2. The steel storage area at a US-based steelmaker lit with conventional fluorescent lights (top), and after retrofit with intelligent LED lights. Measured savings of energy for lighting across the whole company (Kenwal) go beyond 90%. (Image courtesy of Digital Lumens).

how intelligent LEDs equipped with integrated controls, wireless networking and sensors in every fixture are actually used to go much beyond the simple energy savings achieved when traditional fluorescent lights are replaced by light emitting diodes (Fig. 2).

The hands-on activities and tutorials include the study of the Internet Protocol-based energy management strategy to optimize resources, and dramatically increase energy savings company-wide [26], by increasing the awareness of energy consumption providing real-time and easy to use data.

Again in an interdisciplinary view, students will be surprised to learn that while Energy and facility managers found the information provided by energy dashboards (displaying the building's real-time energy use) installed at large community buildings highly useful to detect and correct building energy issues, resulting in a significant decrease in both natural gas and electricity consumption, the same information had little visible impact on students and staff [27].

Finally, two field trips at selected sites where significant technical solutions have replaced inefficient energy use, and renewable energy technologies supplement part of the energy demand, add practical relevance to the course.

Originating in Europe, the course conforms to EUREM duration requirements, consisting of 80 units (90 min) of lectures and tutorials, followed by a project work covering 80 teaching units accompanied by a professional coach. Likewise to an EUREM course, evaluation of participants is carried out through one written test at the end of the course (50% of the marks), followed by an oral presentation at the end of the course when each candidate is asked to present the outcomes of an energy management project to an evaluation panel which assesses the validity of the energy efficiency measures *and* investments.

6. Educators and educational materials

To shape the multidsciplinary competencies invoked in the present study, the course's program is held by educators with a similarly broad background. The main educators, in other word, are energy professionals and managers with an integrated cultural background which includes scientific and management education [28]. Having a strong practical orientation, furthermore, about one third of the course lectures and tutorials are given by leading external practitioners of the energy efficiency and renewable energy industries.

Carefully produced and made available as digital teaching slides, photographs and videos, the multimedia teaching material includes a selection of thoroughly selected scientific articles and updated technical reports.

The course reference books are *Freedom from Command and Control* [29], *IP-Enabled Energy Management* [30], and *Power Density: A Key to Understanding Energy Sources and Uses* [31].

Smil's research on energy has resulted in a strategic, long-term vision of energy that should be common knowledge among today's Energy managers. Similarly, the highly effective applications of systems thinking to management as devised by Seddon in the last two decades has significant implications for better energy management as proposed by the present course. Working with staff workers and with top management to improve the way energy is actually used across the whole organization, the Energy manager will, for example, help managers to improve the organization's ability to respond flexibly to customers, which translates into reduced stockpiling of unsold goods in manufacturing, and thus in considerable energy savings.

By teaching managers to map end-to-end flows of work, separating customer value work from non-value work, the organization's managers will be able to remove waste, reduce variation, inventory, time to process orders, and all sort of non-value activities related to useless reporting, internal goals-related measures and budget.

In this way, energy management will be prevented from becoming another conventional managerial acitivity whose *de facto* purpose becomes 'to make the budget at all costs' [32]. Hence, rather than to start tools-based improved programs to improve performance with more of the same-logic, starting to manage energy gives the opportunity to take a new view of the organization as a whole, and undertake action to improve the system's design.

Furthermore, systems thinking will help in developing better interventions to improve energy efficiency by working on the interactions among technology, facilities and people, namely the main components of each organization (the system) [33]. Future Energy managers taking part into the course, for instance, might be surprised to learn that poor utilization of heating and cooling technology in school building may lead to 45% higher than expected energy consumption [34]. In other words, the impact of how technology is used on overall energy utilization is very often significant, which brings us once again to the need to develop effective management skills.

Finally, as it happens with most Energy manager courses in which participants generally have several years of work experience in different sectors of the economy, the course is held in a collaborative learning environment in which participants actively work together and learn from one another as each participant is 'an explicit and valuable part of another participant educational experience' [24].

7. Outlook and conclusions

We describe the cross-disciplinary approach and contents of a new cross-disciplinary postgraduate course ('Lean and green') aimed to turn participants with different background in economics, management, physical science and engineering into managers able to effectively manage energy at both service and manufacturing organizations. Its effective teaching requires a similarly broadened

educational background of educators which should include systems thinking.

Financed since the early 2000s by the European Commission, the EUREM training project started from the outcome that 'change is personally' [35], namely that 'whitout the involvement of competent and convinced energy managers, change in energy utilization in companies is difficult and seldom practicable'. Indeed, ever more empirical studies find that successful energy management for sustainability requires highly motivated, flexible professionals with an indefatigable positive attitude skilled in the art of persuasion and personal networking [36].

The course described herein targets the education of said 'competent and convinced managers' starting from the premise that, even though the Energy manager role has already been 'professionalized' in many countries enforcing educational standards, code of ethics and continuing education, management is *not* a profession [24].

Energy management is a true managerial activity which cannot dispense from learning management theory and practice. The need to renew current educational practices derives precisely from the poor integration between management on one side, and science and engineering education on the other.

Tomorrow's Energy managers with largely improved management abilities will play a central role in ensuring the global transition to sustainable development, while keeping their organizations thriving in the global economy. By identifying and implementing energy efficiency and new energy technology solutions, properly educated Energy managers will work with top management at reshaping the way most organizations work, teaching managers to stop their disengagement from the shop floor, to rather focus on managing and improve the organization as a system. This, inter alia, will solve most performance issues, which often include poor energy efficiency and little or no use of renewable energy, while providing numerous non energy benefits including enhanced work quality, and a better workplace for all people involved in widely different organizations.

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