Development of a global energy management system for the life sciences industry: an energy management maturity model implementation

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1 Abstract

The Global Energy Management System (GEMS) research project proposes a novel methodology for assessing capital energy-efficiency projects at a global level. The paper scope covers the systematic development and implementation of a methodology that supports sustainable decision making based on the following four pillars: (1) Site Characterisation: understanding what drives energy use on each site. (2) Performance Evaluation: comparing a site's energy performance over time, against the global network and external peers. (3) Shared learning and dissemination: ensuring the best methodologies are proliferated across the network (4) Corporate Policy: investment strategies based on the value of energy incorporating standard financial performance metrics, business continuity process (BCP) and corporate social responsibility (CSR).

In particular, this paper presents the development and implementation of an energy management maturity model as a fundamental step in two of the above pillars: Site Characterisation and Performance Evaluation. The energy management maturity model aims to provide a global view of the overall network readiness for engaging in energy efficiency activities and a baseline from which all sites can improve from.

2 Introduction

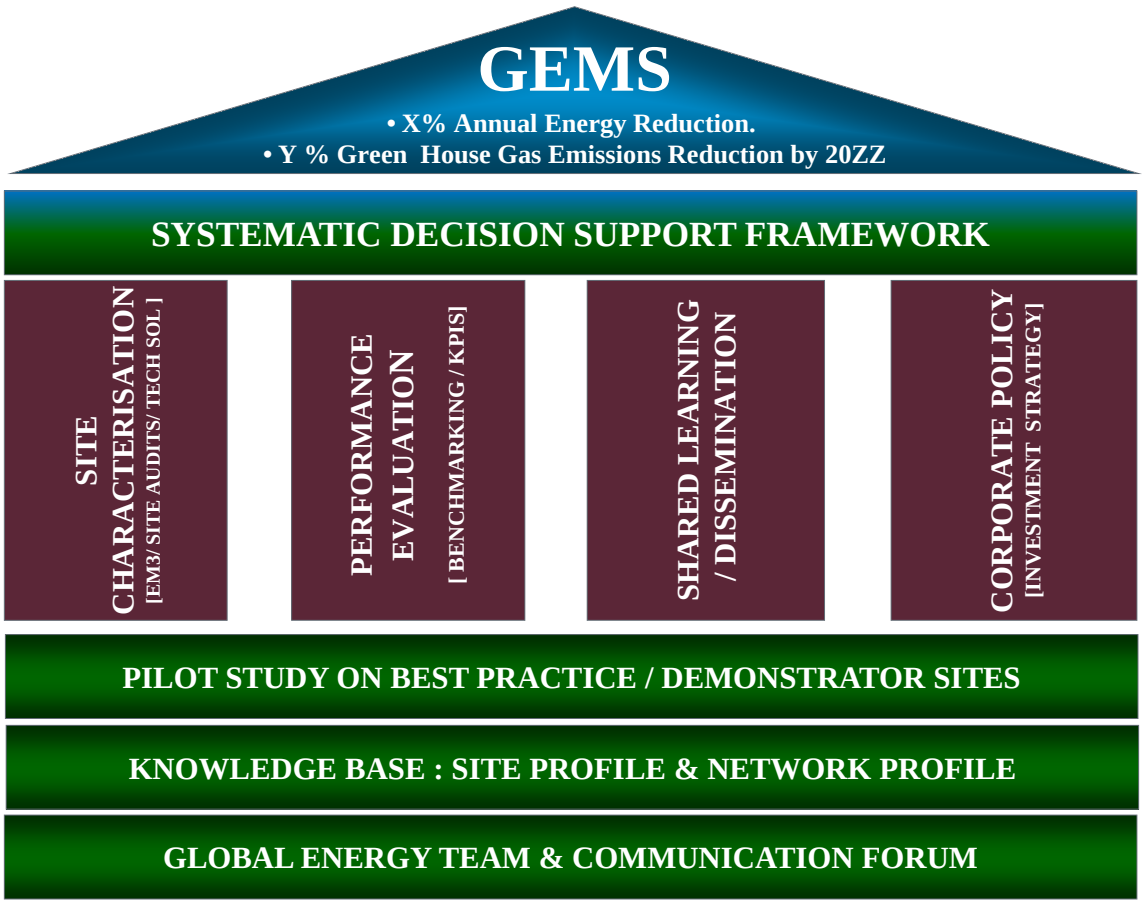
Sustainability of the world's energy resources is a major challenge for humanity today. Global energy consumption has risen enormously over the past century due to population growth, increased industrialisation and increasing energy use per capita. This growth has been largely associated with finite fossil fuels (oil, coal, gas) in industrialized nations, which, at its current rate, is unsustainable. This trend is set to continue with world energy consumption predicted to rise by 56% from 553EJ in 2010 to an estimated 863EJ by 2040 (Leahy et al., 2013). In 2013 the monetary value of the global energy consumption sector grew by 5.3%, which represented a new total value of $8,490.6 billion (Marketline, 2014). This sector is defined as the energy consumption by industry, transport, residential, commercial, agriculture and fishing consumers and markets. This value is projected to grow a further 33.4% by 2018.

Industrial production and processing consumes a significant portion of global energy resources. In the EU-27 alone, it is estimated at 25% of the total energy requirements (Pérez-Lombard et al., 2008). Between 2000 and 2010, energy efficiency in industry has on average improved by 1.3% per year (with further improvement using existing cost-effective energy solutions as realistic target).

Within the industrial sector, there is an estimated 112 million ft^2 of energy intensive cleanroom floor space worldwide of which, the medical device industry alone accounts for 6% (R. McIlvaine, 2015). Manufacturing cleanrooms are 10 to 70 times more energy intensive than a naturally ventilated space open plan office space (Xu, 2008).

Investment in energy efficiency by the industrial sector is thus critical to a sustainable future and progress has being made, particularly in the past decade. Some of the largest consumers of energy come from the multi-national sector, typically with large industrial bases spread across the globe to meet market demands. For most global enterprises, the consumption of energy and natural resources represents a major overhead and developing sustainable energy policies can represent a significant competitive advantage due to growing price of energy and volatility of supply. This symbiotic relationship needs to be harnessed. It enables the mutual benefits of increased industrial efficiency whilst allowing the transition to a sustainable, renewables-based energy future.

This research is embedded in the development of a novel methodology for driving optimal energy efficiency and assessing capital projects at a global level. The 'Global Energy Management System' (GEMS) incorporates best-practice energy assessment guides and standards, in combination with site-level energy and utility data, as well as global economic and climatic data. Ultimately GEMs will deliver a novel methodology and decision support framework for assessing capital energy-efficiency projects at a global level whilst in parallel delivering optimal network energy efficiency performance. The scope will cover the systematic development and implementation of a methodology based on three foundations elements and four pillars as shown in Figure 1.



Strategic plan overview (G.E.M.S.)

Figure 1. GEMS overview.

2.1 Foundations

Global Energy Team & Communication forum: Centrally lead team with representation from each site ensuring effective information sharing & relationship development via shared meeting technology.

Knowledge base Site & Network Profile: Utilize a central platform for data collection, aggregation & analysis. Alignment of cost codes and establishment of Network 'Wheel of Spend' are key steps.

*Pilot site assessment / Demonstrator***:** Utilise the overall network business case to secure project funding & deploy a suitable pilot prior to full network implementation.

2.2 Pillars:

Site Characterisation: Deploy a bespoke 'GEMS' audit to understand the building characteristics of each site and establish the 'drivers' for energy consumption using key tools such as regression analysis. Align identified energy saving opportunities to appropriate technologies. Baseline each site via a qualitative Energy Management Maturity Model (EM3). Complete an enterprise level metering gap analysis.

Performance Evaluation: A novel benchmarking approach by combination of both quantitative KPIs and qualitative EM3 results. The KPI's will be established to track performance at both a site and enterprise level. Data normalization of controllable (processes, technologies, organisational procedures) & un-controllable (externalities such as climate and economics) parameters is required to ensure meaningful benchmarking (site to site & external peers).

Shared Learning/ Dissemination: Ensure best methodologies, appropriate technological solutions and opportunities are proliferated across the network via a global communication forum leading to optimum network energy performance. Raise the profile of the global energy team within the organisation.

Corporate Policy: 'Level the playing field' by developing a novel 'financial' energy metric that reflects the combined positive impact of operational savings, improved sustainability and a more resilient site infrastructure as part of a multi-criteria decision support system based.

2.3 Decision Support System (DSS)

In alignment with the corporate policy, site-level and global metrics are combined with the proposed energy savings providing the global energy manager an invaluable decision support framework. It will serve two mutually exclusive target audiences from the same dataset:

Clear presentation of energy opportunities to the executive leadership. This informed decision making will ultimately lead to increased funding for energy efficient projects on a global scale.

Normalised benchmark performance for the site energy manager. This will enable each site in the network to work towards optimal energy efficiency following a structured, informed and fair framework.

The GEMS methodology is being applied to a Fortune 500 global leader in the medical device sector – Boston Scientific Corporation.

3 Literature Review

Literature on energy management is vast and, to ensure a meaningful review, the following boundary conditions were applied:

- The scope is limited to the physical boundary of the site(s) or organisation in question. Determining the energy and greenhouse gas emissions associated with each stage of the supply chain was deemed overly complex without adding value (Whaley, 2014).

- The scope will not include solutions or approaches to improve or reduce energy consumption at production floor level, as this is typically not under the control of a facilities department, thus difficult to influence.

Initially, the various established approaches to management and planning at an enterprise level were reviewed, followed by their adaptation into energy management. The literature of interest identifying the significant activities in energy management is vast, comprising of good practice guides, scientific articles and texts covering energy management systems. For clarity, the review was broken into three main categories, namely: standards, industrial guidelines and scientific literature.

Standards such as ENERGY STAR™ (US EPA, 2013), ISO50001 (ISO, 2011) and SEP (US Department of Energy, 2012) offer the best available support to an individual site energy manager. The resources are freely available and the overall guidance provided is of a very high standard most notably ENERGY STAR™. None of the standards, however, offer a clear approach to tackling energy management and capital spend efficiencies for a multi-site organization with a global footprint.

A review of current best practice approaches to corporate energy management suggests a silo approach between corporate policy and the individual sites. Cross communication between sites is rare.

A gap exists in translating corporate social responsibility and business continuity into shareholder value. A corporate strategy is needed to buy-in on energy projects that might otherwise be seen as non-runners when compared with traditional process improvement projects or other more directly lucrative capital investments.

Global energy management activities are not well defined in the reviewed scientific literature (Antunes et al., 2014). Energy management and its associated practices vary greatly mainly because there is no well-understood energy management model. Furthermore, despite the existence of several guides to assist companies in implementing energy management activities case- studies show that real-world implementations of energy management programs fail to cover the breadth of energy activities defined in these guides. Similar to established standards much of the facility management research to date is ‘site’ focused with little practical guidance for the global energy manager.

Based on the literature review, it is evident that current approaches to energy management systems are sufficient for individual sites but are not adequate to meet the requirements of a multi-site enterprise with a diverse global presence. Even in situations where individual sites are strong performers on energy, an over-arching decision support framework is required to ensure maximum return on investment of energy related capital expending at corporate level. The lack of such a decision support system may result in significant inefficiency and under-funding in energy related capital projects.

In order to build such decision support framework and drive an energy reduction program or policy in a multi-site corporation with global presence, a global energy manager needs to:

- Understand the current status of the network;
- Develop a roadmap that enables the organisation to enter into a momentum of continuous improvement.

The first point would require a site by site characterization based on energy management principles (Carbon Trust, 2011; ISO, 2011; US Department of Energy, 2012). The second point touches on the definition of Maturity Models (Paulk et al., 1993; Wendler, 2012; Antunes et al., 2014). Combined, it becomes clear that an Energy Management Maturity Model is necessary to tackle both points in the journey towards a global decision support framework.

Reviewed literature suggests maturity models are in their infancy in the energy management sector. Despite an upsurge in the area of energy management, there is a striking gap between current literature and practical implementation of energy management practices (Antunes et al., 2014). Similarly, (Introna et al., 2014) reiterate this issue, stating "with regards to energy management, existing tools are still not well-structured and do not allow a deep analysis of the level of maturity of an organization and of how this maturity develops along with its dimensions". Finally (O'Sullivan, 2011), highlights the advantages of implementing and energy management maturity model as an strategy to maximise the impact of energy efficiency measures.

However, such approach potential resides in the ability to deliver insight to understand the current stats of each site in the network while also allowing a two-way evaluation where the view of the sites with respect to global policies and practices is also reviewed.

4 Approach

In this section we propose an Energy Management Maturity Model (EM3) targeted for a multi-site organisation. The approach aims to characterise and benchmark each site and the whole 'network' of sites in terms of the technical and non-technical readiness to implement energy efficiency actions. The EM3 is not intended as a best-practice guide but rather as a tool for defining the continuous improvement roadmap in a synergistic manner between the individual sites and the whole network. This research work gets inspiration from several other approaches (Antunes et al., 2014; Introna et al., 2014; ISO, 2011) but included elements gained through experience on interacting with global energy managers in different organisations. The EM3 is divided into two main parts:

- A questionnaire to be applied to the individual(s) responsible for energy management on each site;
- An evaluation framework and continuous improvement roadmap that can be directly and automatically extracted from the results of the questionnaire.

Before moving to explain the addressing of the two aforementioned points, some key concepts need to be clarified as the different points of view targeted in the EM3:

- *Site view*: individual facility that takes the questionnaire;
- Network view: the combined, averaged, view of all facilities in the enterprise with global presence;
- *Corporate view*: the view of the global energy manager or the global energy team with respect to the internal network of sites;
- *Global view*: the view of the global energy manager or the global energy team with respect to the external organisation peers.

4.1 The questionnaire

The questionnaire is the central piece of the EM3 as, once it is applied, it allows extraction of all the relevant information from each site and the network. The questionnaire also enables a survey the network's perception on some key aspect of corporate energy management. In this sense, the questionnaire is divided into three sections one for each stage of site, corporate and global. Each of these sections groups the questions in the one of the four phases of Plan-Do-Check-Act which are the divided into key steps as follows:

- *Site*: is a set of nine key areas aimed at understanding where each site is in terms of an energy management maturity model.

Plan

Commitment	Assesses the existence of an energy manager, an energy management team, an energy policy and the site's management commitment to energy efficiency.
Energy planning and review	It is used to understand the site's policy towards collection, processing, communication and dissemination of energy performance data.
Action plan	Evaluates the site's policy towards the implementation of energy performance measures, including evaluation criteria and investment levels.
Do	
Implementation (people)	Gauges the importance given by the sites to personnel energy training, personnel awareness and dissemination of energy management measures.
Implementation (processes)	Evaluates how energy efficiency measures are documented and stored. Also, how normal operation and management practices incorporate energy efficiency measures. Finally, how energy efficiency practices are applied to space designing and suppliers choice.
Check	
Measurement and verification (M&V)	Evaluates the M&V policy of the site including how data is visualised and how results are reported.
Compliance and audits	Used to understand if energy audits are applied, who requests the application of energy audit, how are these carried out and whether or not there is a policy to audit the entire value chain.
Act	
Management review	Measures the level of site's implementation of energy management systems.
Recognition	Measures the levels of internal and external recognition of energy efficiency actions. It also evaluates the engagement of the site with local communities and authorities on energy efficiency.

- **Corporate**: consists of eight key areas and is aimed at using sites' average score as a benchmark for how the corporate approach to energy management and maturity is perceived.

Plan	
Team	Evaluates the existence and engagement of a coordinated global energy team.
Data analysis and benchmarking	Assesses the interaction between site and corporate level in relation to operational expenditure. Also, it evaluates the level of detail known on the splits of energy use and the level of harmonization of cost codes across sites.
Best practices	Determines the indicators used for assessing energy management at corporate level.
Do	

Benchmarking	Evaluates cross-site energy consumption comparison levels and data normalisation. It also evaluates how energy performance indicators are integrated into the enterprise-level energy management system.
Skills and communication	Evaluates the existence and engagement of a corporate-level communication forum, the resources assigned to it and the corporate policy towards energy training for site level energy managers.
Corporate assessment metrics	Determines the indicators used for assessing energy related capital expending at corporate level.
Check	
Decision Support	Assesses the existence and indicators used for corporate-level decision support on energy-efficiency related capital expenditure.
Act	
Performance sustainability targets	Evaluates existence and pursue of corporate level sustainability targets, their update frequency and the inclusion of business continuity into the sustainability targets.

- **Global**: incorporates the EDF Smart Energy Diagnostic Survey questionnaire (EDF Climate Corps, n.d.), into the EM3 aiming at benchmarking the corporation against industrial peers in a global scale.

In our approach, the corporate and global section of the questionnaire are applied to each site of the network and also to the global energy manager/management team. Such implementation seeks to gauge the level of understanding from each of the sites towards the corporate policy for energy management and take corrective actions where necessary to align site's view with corporate view.

In an implementation note, each of the questions in the questionnaire had five possible answers to choose from which will then serve to give marks to each questions depending on the selected answer.

4.2 Evaluation framework and continuous improvement roadmap

The evaluation framework is established by the definition of five maturity levels, each one representing an incremental step in the energy maturity journey from the previous maturity level in the key areas under the scope of the EM3. The maturity levels are shown in Figure 2 and explained below.

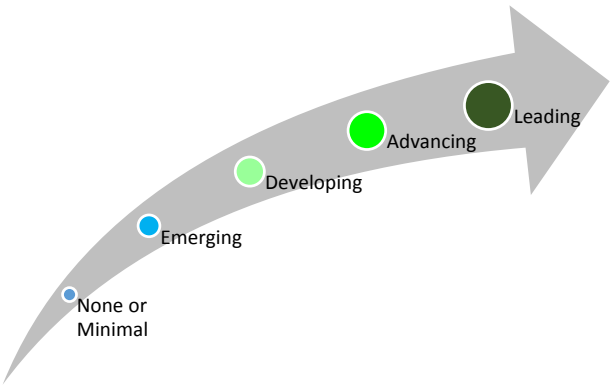


Figure 2. Maturity Levels

In general terms the Maturity Levels can be defined as follows:

None or Minimal	This is the first step in the energy journey and in general it corresponds with the situation where there is no energy policy within the organisation.
Emerging	Organisations in this level would have started the energy journey by defining an energy policy and is aware of energy performance.
Developing	Here the organisation is half way through the energy journey, it would have and enact an energy policy and start taking measures towards improving energy efficiency.
Advancing	In this level the organisation consistently takes measures for improving energy efficiency, not only within the same organisation, but also reaching local/national authorities and communities.
Leading	This is the final step in the energy journey as currently conceived and corresponds with an organisation that becomes a beacon for energy efficiency good practices.

The scoring system, based on the maturity levels aims to quantify qualitative aspects related to the EM3 to provide the incentives and the basis for developing an actual tangible roadmap for continuous improvement. With respect to the key areas addressed by the questionnaire, the following Table 1 and Table 2 relate the overall requirements of each of the maturity levels corresponding with the Site and Corporate Levels respectively. For Global level please refer to the EDF Smart Energy Diagnosis Rubric (EDF, n.d.).

Table 1. Site level maturity levels vs. key areas.

	None or Minimal	Emerging	Developing	Advancing	Leading
Plan					
Commitment	No EM / EMT, no SM commitment to EE, No Energy Policy	EM exists with limited training, experience, recognition and action documentation. SM aware of energy	EM has sufficient experience and training but limited responsibilities SM is reactive towards EE. Energy Policy is incorporated and documented but with limited scope	EM has adequate training, responsibility but limited authority. EM is supported by an EMT. SM proactive towards EE. Energy Policy has broad scope including different site areas and is well known internally	EM is certified, has adequate authority. SM is involved in EE. Energy Policy communicated externally. EMT is cross functional and has continuous training
Energy Planning and review	EPD is never collected and/or reviewed	EPD collected and occasionally reviewed through bills is the main source of information. Benchmarking performed against same site at site level. Audits on major equipment. Site level KPI. Limited goals	EPD analysed regularly and predicted with ad-hoc tools and reported. Cost analysed from bills with a split for major areas. Audits performed regularly. Benchmarking within same organisation. KPI for MEU and source. Site level goals and for MEU communicated internally.	EPD analysed with specific tools. Sub-metering for MEU in place. Site compared against other facilities in the same sector. Opportunities periodically reviewed and pursued. KPI for MEU include drivers and split by final use. System level goals defined, periodically reviewed and communicated internally	EPD automatically analysed. Energy costs reviewed frequently. Energy tariff reviewed by third party. Sub-metering includes other energy users. Site compared against different sites at different levels. EEM are continuously pursued site-wide. M&V plan used. Energy Policy defined for most areas and externally communicated. KPI defined for most energy users. KPI normalised.

Action Plan	No planning nor investment on EEM	EEM depend on general funding and are considered only after major anomalies are detected	EEM can be proposed by ET and are assessed based on economic considerations. Moderate investment in EEM in place	SM, EM and technical personnel can proposed EEM which are assessed considering also environmental factors. Funding for major EEM in place.	All personnel can propose EEM which are assessed also on CSR metrics. There is dedicated funding for EEM comparable to core business funding
Do					
Implementation people	No training, awareness nor communication platform	Informal training to ET. Awareness reaches only few levels and awareness campaigns are sporadic with limited funding. No resources allocated for energy-related communication	Frequent training on energy management to ET and SM. Promoting awareness becomes site's policy. A communication platform for sharing documentation exists	A comprehensive and frequent energy training programme exists delivered also to some other personnel. Site's policy is to promote awareness at all levels and high level of resources are allocated to it. A dedicate communication manager exists to deal with energy matters. The communication platform allows tele-conference	Certified energy training is provided and available to all personnel. Awareness campaigns are a priority and engage internal personnel and general public. The energy team communicates with all areas with dedicated resources.
Implementation process	Energy O&M only performed for business continuity. Space design, materials and suppliers are defined on aspects unrelated to energy	Energy actions internally documented. Energy O&M performed when anomalies are found. Energy is somewhat considered in space design, materials and suppliers choice	Energy actions are documented on digital format following structured and formal approach with access to some personnel. Energy O&M performed regularly by ET. O&M team is aware of energy matters. Energy is prioritised for space design, materials and suppliers selection	Energy actions documentation accessible to personnel in all areas. Energy O&M seeks low-cost actions continuously. Space design and materials selection use modelling and simulation for performance evaluation. Equipment selection is based on energy performance	Energy actions documentation accessible to all personnel. Energy O&M is comprehensive with interventions planned and communicated. At least one member of O&M team is energy certified. LCA is performed for space design, material and equipment selection. Energy is a major consideration in the whole supply chain
Check					
M&V	Utility meters used. Data stored ad-hoc. M&V inly on major energy users. Analysis using ad-hoc tools	Major systems occasionally checked for identifying energy consumption. A measurement system is partially developed in-house. M&V is frequent for major energy users. A standard platform is used for analysing data	Major systems periodically checked. Fully development collection and storage system. M&V is incorporated in O&M for major energy users. Advanced visualisation used for data analysis	Most systems/areas monitored occasionally. A standard M&V protocol partially implemented. M&V has a stand-alone system for major energy users. Statistical analysis used for data analysis	Most systems and areas are periodically monitored. A standard M&V protocol is fully implemented. M&V is planned for most spaces regularly. Advanced analysis performed through data aggregation
Compliance audits	No internal nor external audits carried out	Internal audits planned. Suppliers audit planner. External audits performed based on external request, by a third party and results communicated to SM and ET	Methodology for internal audit exists but is rarely used. Known to ET and some personnel. Only major issues addressed after audit. External audits are periodic on customer demand. Results communicated to some personnel in MEU	Audits are widespread, regular and well communicated. Most issues addressed after audit. Suppliers audited occasionally. External entities are invited to perform audits with results communicated to all personnel. In-house auditing methodology in place	Standardised auditing methodology in place. Results communicated internally and externally. All issues addressed. Suppliers audited regularly. External audits are invited and performed by some State entity, following standardised approach and with results broadly communicated

Act					
Management Review	No EnMS	EnMS is being implemented. SM is planning to review EnMS	EnMS is fully implemented. SM occasionally reviews the EnMS	EnMS is implemented, actuated and certified by a third party. SM regularly reviews the EnMS	EnMS is certified and integrated with other management systems. SM consults with third partied for reviewing EnMS
Recognition	No incentives for EE actions. Site is not energy certified	Incentives for EE actions are being planned. Energy certification is planned. Initial contact with authorities in place. Information on energy matters is shared	Occasional incentives given to EM for EE actions. Site is energy certified but outdated. Sporadic support to local communities on energy awareness	EE actions informally rewarded. Resources allocated for selected personnel to implement EE actions. Site has been recently energy certified. The site frequently supports local communities in EE projects/campaigns. The site is used as demonstrator for awareness campaigns. Internal information on energy matters is shared	EE actions are rewarded under a formal programme. Resources for implementing EE actions are available to all personnel. Site is continuously energy certified. The site in engaged with local authorities and communities to support EE actions, share knowledge, develop policy and create awareness campaigns. The site is active in media in promoting energy efficiency

EM: Energy Manager
SM: Site Management
EE: Energy Efficiency
EMT: Energy Management Team
EPD: Energy Performance Data
MEU: Major Energy Users
EP: Energy Policy

Table 2. Corporate level maturity levels vs. key areas.

	None or Minimal	Emerging	Developing	Advancing	Leading
Plan					
Team	Non existent	Is unofficial with limited resources	Is official but with irregular meetings. Personnel resources are part-time. Energy is low priority	Officially exists and meets periodically. Part-time personnel resources. Energy is equal priority to other areas	Officially exits and meets regularly and with a defined structure. Full time resources and a global EM exists
Data Analysis / Benchmarking	No knowledge. Each sites tracks energy spent individually	Overall OPEX is known by site. Each site manually update GEM on OPEX	OPEX is known and split into main uses. Manual tracking through a global analytics system	Wheel of spend is established globally. Central automated tracking, analysis and payment system for the majority of sites	Wheel of Spend is established for each site and harmonised thorough all the sites. Central automated tracking, analysis and payment for all sites
Best practices	Forecasted ROI only	Forecasted ROI with associated sustainability impact	Forecasted ROI (based on opportunities list) with associated sustainability impact	Opportunities list reflecting the positive impact on operational savings, sustainability and business continuity	Complete business case reflecting impact on stock parameters (e.g. market value, annual revenue required for off-setting investment)
Engage executives	No goal	regional or departmental, intensity-based goal	organisation-wide intensity goal	regional or departmental absolute goal	organisation-wide absolute goal
Do					

Benchmarking	No site characterisation. No KPI used	Site's energy used split by source. Audits required on each site. Some sites have local benchmarking. Site level KPIs	Energy consumption split by MEU. Each site is audited by a global partner. Sites benchmarked quantitatively. Site. And global-based KPIs used	Sites energy data normalised by climate and economics. A sensitivity analysis on energy uses is performed on each site. Benchmarking of sites is quantitatively and qualitatively. Site and global KPIs combined in enterprise-level EnMS	Energy data normalised to all relevant variables. Site's audits and opportunities list are part of global database. An EM3 is used for benchmarking. Enterprise-level EnMS includes KPIs and EM3
Skills and communication	No structure. No dissemination	Global forum in place for basic inter-site communication. Global and local individuals provide basic energy training	Global forum that allows presentation and dissemination of key topics. Global basic training programme in place for all energy stakeholders	Best practices based global forum for easy access and inter-site and external communication. Global intermediate training programme in place for all energy stakeholders	Enhanced technology for efficient transfer of inter-site best practices. Global advanced training programme in place for all energy stakeholders aligned with external accreditation
Corporate assessment metrics	ROI short term	ROI short term and impact on sustainability	ROI medium term and impact on sustainability	ROI medium term combined with impact on sustainability and qualitative reference to business continuity improvement	Single financial energy metric that reflects the combined positive impact of operational savings, improved sustainability and a more resilient site infrastructure as part of a multi-criteria decision support system based
Check					
DSS	Each project is assessed in isolation, local site impact only.	Each project is assessed in isolation, global impact.	Each project is assessed against a global database to ascertain the optimum investments and benchmark against historical projects	Each project is assessed against a global database to ascertain the optimum investments and benchmark against historical projects. Site-level and global KPI's in conjunction with a site maturity model is considered. These are combined with a list of ECO's (and associated performance risk)	Software platform to support previous
Act					
Performance sustainability targets	No global targets for energy consumption reductions or GHG emissions reduction	Targets in place but not officially approved by EC	EC approval of annual targets	EC approval of 5 year targets with annual review	EC approval of 5 year targets with annual review. Agreement on strategy for value associated with sustainability and business continuity impacts

EM: Energy Manager
SM: Site Management
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For each site in the network, the continuous improvement roadmap is then given by two elements:

- Development of an individualised Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis that effectively benchmarks each site against the network (Figure 3).

Each facility is then requested to address the found weaknesses and plan contingency actions for the threats. This will effectively level each site with regards to the network.

- The natural improvement approach given by the framework between PDCA and maturity levels. The approach requires that the less mature PDCA elements are addressed before advancing the higher ranking ones.

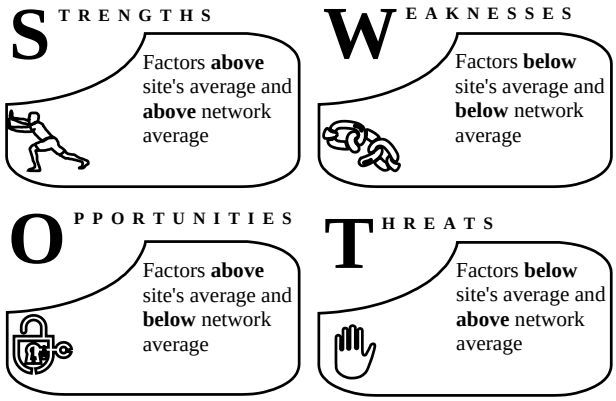


Figure 3. SWOT analysis

The reasoning behind this particular implementation of the SWOT analysis is straightforward and performed from a site's point of view relative to the network:

- *Strengths*: are elements where the site excels when compared with both the network and itself;
- *Weaknesses*: are elements that the site needs to improve when compared with itself and the network. in this case, the network averages above the site for the particular factor and therefore it is possible for the site to gain the necessary maturity level through network expertise;
- *Opportunities*: are factors that the site excels when compared to itself but is below when compared to the network. By being below the network is provides an opportunity to improve even though priority for addressing factors should be given to weaknesses
- *Threats*: are elements that are below site's average but also above the network average which prevents that site from gaining the required expertise to level the factor from the network.

The condition to be above or below network average includes a dead band, in our case of 0.5 points chosen arbitrarily to narrow the factors on which to focus the SWOT analysis.

With the SWOT and the natural evolution of maturity level, each site in the network must prepare a short and medium term action plan that would be reviewed yearly in order to track progress and results.

From a Corporate/Global perspective a similar approach is pursued but with the Corporate section of the questionnaire. In the case of the Corporate perspective, the averaged network view of the Corporate questions is taken into account for particular areas where the misinformation or needs are perceived by the sites.

5 Implementation: Case Study

Boston Scientific Corporation (BSC) is a medical device manufacturer with a presence in over 100 countries globally. For this research work, the entire manufacturing network of 16 sites was chosen comprising some sites with predominant manufacturing space and other with

predominant office spaces. These serve as the starting point in the implementation of the EM3. Such sites not only comprise a mixture of space types and sizes, but also of building ages (1980-2010), climates and economics (North America, Central America and Europe) and building technologies.

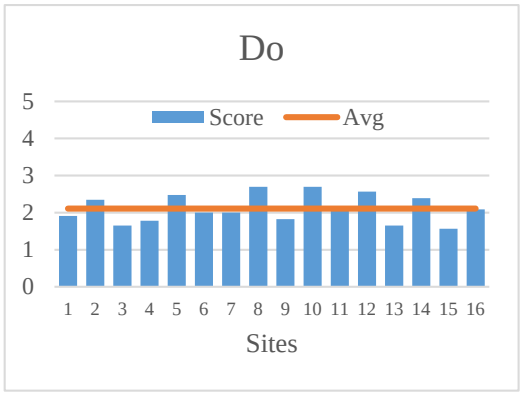
The EM3 model was applied to the 16 sites in BSC with the support of EDF following the steps shown in Figure 4.

Figure 4. EM3 Implementation Steps

- *Questionnaire application*: the questionnaire as previously presented, was applied to each site. In particular, a teleconference was scheduled with the responsible for energy management on each site. A day prior the conference, the questionnaire was emailed to the designated responsible and during the application of the questionnaire, doubts were addressed.
- *Result compilation*: after each questionnaire application, the numerical results corresponding with the marking given to each question were compiled in a spreadsheet for further analysis.
- *Data aggregation*: questionnaire results from each site were aggregated to provide network averages that serve to show a corporate positioning in relation to PDCA and the maturity levels.
- *Data comparison*: finally, all the sites were compared and results are shown in Figure 5 and Figure 6.

5.1 Site questions

Figure 5 shows the averaged network results of the site questions applied to all 16 BSC sites.



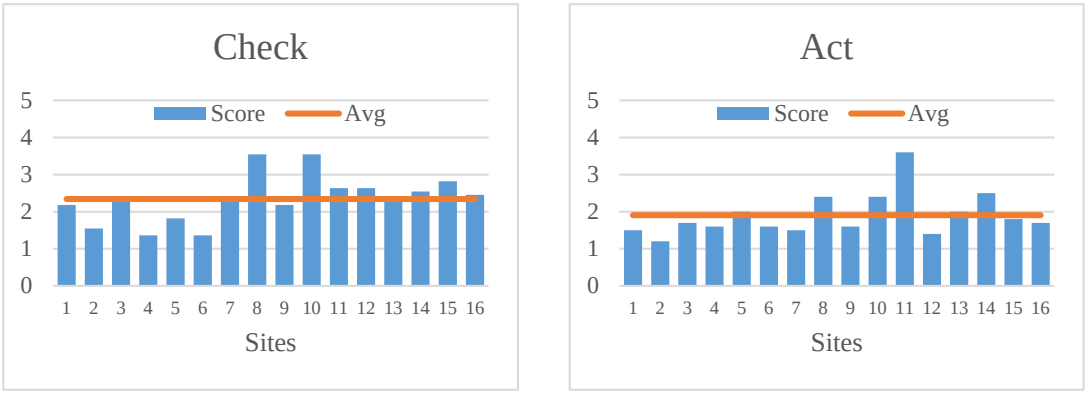


Figure 5. PDCA scores for the site-level questionnaire applied to the 16 surveyed BSC sites.

From Figure 5 it can be seen how in 'Plan' most sites are around the network average. However, this trend is not shown for 'Do', 'Check' and 'Act' where it can be seen a growing discrepancy levels between sites' scores. In particular sites 8, 10 and 11 are significantly more advanced than the rest. The SWOT analysis for these sites showed little in the areas of weaknesses and threats which translates in these sites being network leaders in energy maturity.

In average, the network is in a Developing maturity level for 'Plan' while having an Emerging maturity levels in all the other aspects. The network must then focus effort in improving 'Do', 'Check' and 'Act' in order before further improvements in 'Plan' are actually carried out.

5.2 Corporate and global questions

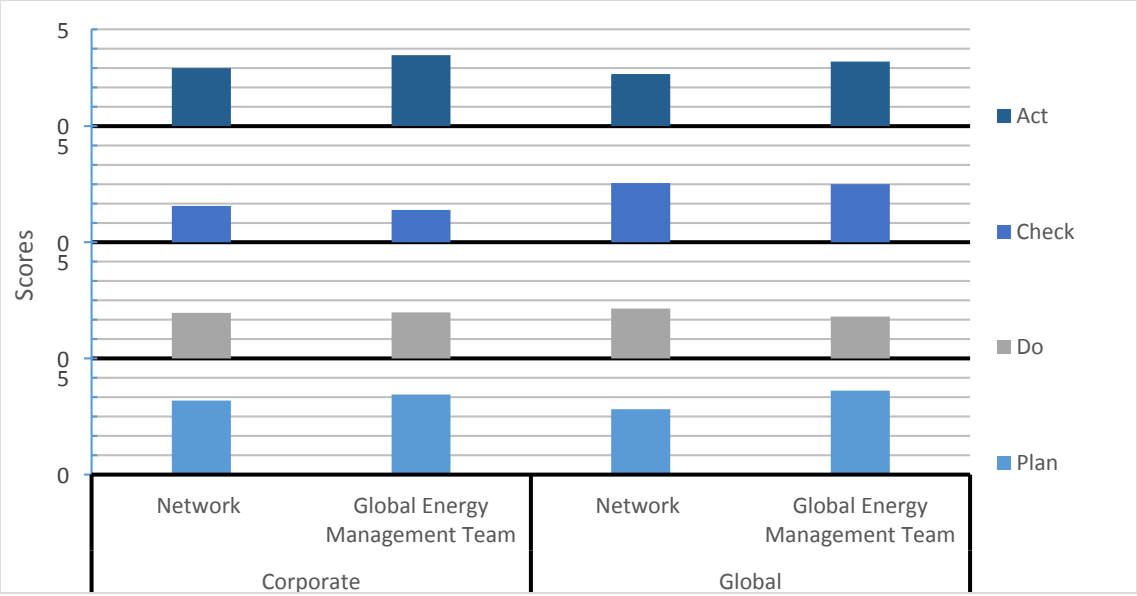


Figure 6. PDCA scores for the Corporate/Global-level questionnaire comparing averaged answers of the 16 surveyed BSC sites and the Global Energy Management Team.

On Figure 6 it can be seen the results for the Corporate and Global sections of the survey. It shows a comparative view between the network and the global energy management team. To note that the Corporate section of the survey was applied to the global energy management team before sites' questionnaire results were aggregated in order to avoid influencing results. It is interesting to note:

- For the Corporate section, 'Plan', 'Do' and 'Check' results are consistent between network and global energy management team, while for 'Act' it is not the case. In such

case it is important for the global energy management team to engage with the sites in informing the factors and elements of 'Act' that the sites are not considering as advanced as they actually may be. It is also important to address the big maturity gap between 'Plan' (Advancing) and 'Check' (None or Minimal) and concentrate efforts on improving 'Check'.

- For the Global section, discrepancies show on the 'Plan' where again the network perspective is below that of the global energy management team.
- For both sections, it is clear that BSC is more advanced in 'Plan' and 'Act' which translates in a need to concentrate efforts on 'Do' and 'Check' for reaching a level scoring.

5.3 Reporting

After the implementation of the questionnaire to all sites and the global energy team, each sites receives a report of their performance based on the areas described in section 4.2. By way of example, Table 3 shows the comparative results of site #9 versus network average for the site questions (score scale 0-5). In red, any area with score below 2.0 which is considered to be the threshold, for BSC; to give any area high priority.

Table 3. Site #9 versus Network average for site questions in the key areas.

	Site	Network		Site	Network
Plan	**2.80**	**2.88**	**Do**	**1.83**	**2.11**
Commitment	2.42	2.60	Implementation	2.13	1.84
Energy Review / Planning	3.00	2.81			
Action Plan	3.00	3.80			
Check	**2.18**	**2.34**	**Act**	**1.60**	**1.91**
M&V	4.25	2.92	Management Review	1.00	1.78
Compliance & Audits	2.01	1.00	Recognition	1.75	1.94

Results from Table 3 indicate that site #9 should concentrate efforts in bringing all the aspects of Act to an acceptable level above 2.0. From a corporate point of view, the most interesting results are on the Network average column showing that overall the network does not perform neither internal nor external audits (Compliance & Audits). In addition, implementation, management review and recognition, all fundamental aspects of a successful EnMS, are underperforming as shown by the Do and Act sections scores.

Table 4 shows the comparative results of averaged network responses versus those of the global energy management team for the corporate questions (score scale 0-5).

Table 4. Averaged network versus global energy team answers for corporate questions in the key areas.

	Network	Global		Network	Global
Plan	**3.83**	**4.13**	**Do**	**2.36**	**2.38**
GFUM	4.07	4.34	Site Characterisation	2.27	2.00
Site Profile & Network Profile	4.00	4.50	Performance Evaluation	2.31	2.00
Best Practices/Demonstrator Sites	3.00	3.00	Shared Learning / Dissemination	2.38	3.00
			Corporate Policy	2.63	2.67
Check	**1.88**	**1.67**	**Act**	**3.00**	**3.67**
Systematic DSS	1.88	1.67	Management Evaluation & CI	3.00	3.67

To note from Table 4 how averaged network and global energy management team views mostly align. This indicates a strong communication strategy on behalf of BSC.

Table 5 shows the comparative results of averaged network responses versus those of the global energy management team versus the approximate EDF 90% results for the global questions (score scale 0-4). In red, any area with score below 2.0 which is considered to be the threshold, for BSC; to give any area high priority.

Table 5. Averaged network versus global energy team answers for global questions in the key areas.

	Network	Global	EDF		Network	Global	EDF
Plan	**2.38**	**3.33**	**4.00**	**Do**	**1.58**	**1.17**	**3.40**
Engage Executives	2.38	3.33	4.00	Invest in People	1.58	1.17	3.40
Check	**2.06**	**2.00**	**3.10**	**Act**	**1.69**	**2.34**	**3.60**
Manage projects and data	2.06	2.00	3.10	Access capital	1.90	2.11	3.20
				Share results	1.06	3.00	4.00

Finally, from Table 5, the same view alignment between network and global can be seen. However, BSC performance, when compared with EDF peers, needs improvement.

6 Conclusions

The implementation of the energy management maturity model proposed in this paper is a first step towards the development of a decision support system for aiding global energy manager in the continuous process of improvement in energy efficiency. In this regard several lessons have been learned:

- The EM3 provided a tool not only to characterise and benchmark all the sites in an organisation with a global presence, but it also allows for the development and application of a common language and common goals towards a unified and globally understood global energy policy;
- The combination of the application of a scoring system, a SWOT analysis and a roadmap for future actions creates incentives and an implementation path for each site to implement measures to become the best it can be;
- The application of the Corporate and Global level questionnaire to each sites delivered insights into the lack of proper information being effectively delivered to the sites from the global energy management team. Corrective actions can now be applied;
- The EM3 provides the global energy management team with a powerful tool to complement the quantitative energy data provided by the facilities with a quantification of the qualitative aspects required for successfully implementing a global energy policy;
- Although some sites are clearly better than others, care must be taken when analysing these results as the variety of building ages, spaces uses and technologies implemented in the facilities may bias such analysis. A normalisation of the results as proposed in the future work is the next logical step to provide a fair comparison between sites. Nevertheless, the EM3 as a site-based benchmarking tool is very valid towards pushing the sites to become the best they can be while pulling required knowledge and elements from the network.
- On an implementation note, it is important that the questionnaire is honestly answered by the person in charge of energy management since not doing so would compromise the future successful implementation of energy efficiency measures and also it would show in the future reviews of the EM3;
- Even though the presented EM3 was applied to an organisation within the life sciences, it can be applied to any multisite organisation of any size;
- Even if the EM3 presented in this research work encompasses several other approaches found in literature it does not include every conceivable aspects of energy management

(e.g. legal issues). Further developments and improvements might be applied to refine and/or extend the models should such unconsidered aspects reveal relevant for the application.

Future Work

Several lines of future work are open as a result from the development and implementation of the EM3 presented in this research work, worth mentioning:

- Development of a normalisation approach for the results including internal sites aspects (e.g. floor space distribution, building age, fuel mix, etc.) and external aspects to the site (e.g. regional economics, energy prices, climate, etc.). This will allow for a fair inter-site benchmarking in future applications of the EM3;
- Integration of the EM3, the normalisation and the quantitative elements resulting from a typical energy auditing into a decision support tool for the global energy management team;
- Quantification of elements relating to corporate social responsibility and business continuity into the decision support tool;
- Short and medium term reimplementation of the EM3 and comparison of new results with the results presented in this research work and associated work plans. This will serve to track the action application of the energy efficiency measures established in the individual action plans.

Acknowledgements

The authors wish to acknowledge support provided in part by a research grant from Science Foundation Ireland (SFI) under Grant Number SFI/12/RC/2289 through a TP agreement between the SFI Centre for Ireland's Big Data and Analytics Research, ZuTec Inc. Ltd and Boston Scientific Corporation

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7 Appendix

Sample report card for Site 7

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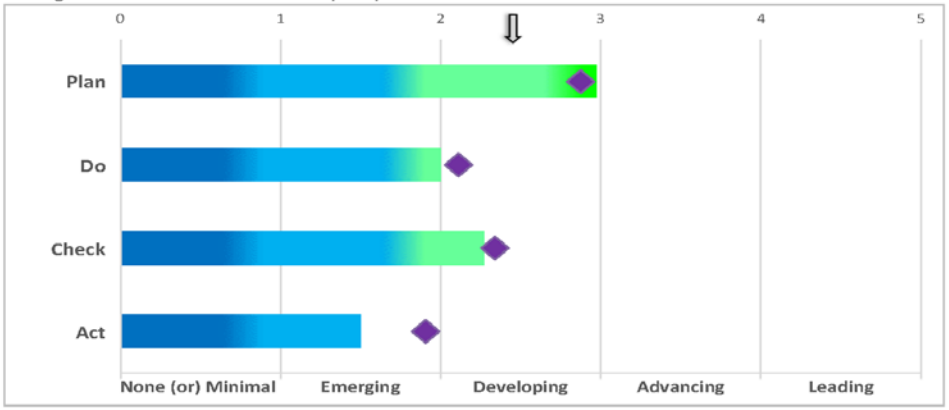
BSC GEMS EM3: Baseline and Benchmark 2015

Below are your site's results from the GEMS Survey and Maturity Model. The graph displays your scores in the four main headings: Plan, Do, Check and Act. The scoring system ranges from 1.0 to 5.0 and positions each of the evaluated aspects in one of the five maturity levels: None (or) Minimal, Emerging, Developing, Advancing and Leading. Also displayed on the graph are the average for Boston Scientific Global Network Sites. For details on how each score was calculated, see the text beneath the graph for the main measured areas. To learn more click BSC GEMS EM3.

Site: 7

27 August 2015 Site GEMS Survey Snapshot



Final Score: 2.45 ◆ Average BSc Network Sites

Legend

	Site	Network		Site	Network
Plan	**2.97**	**2.88**	**Do**	**2.00**	**2.11**
Commitment	**2.42**	**2.60**	**Implementation**	**2.13**	**2.02**
Management Responsibility	3.33	3.04	Training	1.00	1.10
Energy Policy	1.00	1.90	Awareness	2.00	1.78
Energy Team	2.67	2.73	Communication	2.00	2.42
Energy Review / Planning	**3.11**	**2.81**	Documentation & Control	2.33	2.92
Data Analysis & Energy Baseline	3.71	2.98	Operation and Maintenance	3.00	2.73
Benchmarking	3.00	2.81	Design	2.00	2.31
Energy Opportunities Audit	3.25	3.48	Procurement	2.00	2.19
Key Performance Indicators	1.00	1.53			
Energy Goals	3.00	2.33			
Action Plan	**3.80**	**3.80**			
Project assessment & planning	3.50	3.86			
Resources	5.00	3.56			
Check	**2.27**	**2.34**	**Act**	**1.50**	**1.91**
M&V	**3.50**	**2.92**	**Management Review**	**2.00**	**1.78**
Monitoring, Measurement & Analysis	3.50	2.92	Management Review & Recognition	2.00	1.78
Compliance & Audits	**2.01**	**1.57**	**Recognition**	**1.38**	**1.94**
Internal Audits	1.00	1.83	Internal Recognition	1.33	2.08
External Audits	2.33	2.25	External Recognition	1.40	1.85

Final Score = (3*Plan + Do + Check + Act)/6
Section scores average all questions not sub-section average

Grey indicates site score < network average - 0.5 or site score < 2.0
Red indicates network average < 2.0

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GEMS

SWOT Analysis

Strengths	Weaknesses
Site 7 strength compared with other BSC sites lie in the documentation and review of Energy goals. Site 7 is also the only site to have an Energy manager with professional energy certification. Moreover, the site's procedures for collection, documentation and review of energy performance data are well above the rest of the network. The level of investment made at the site in energy efficiency is also a huge plus. In addition, the relation with the local communities with regards to promoting energy awareness makes Site 7 stand out from the rest of the pack.	
Opportunities	**Threats**
Though the energy performance data is collected and reviewed, the site lacks detailed assessment metrics to compare and monitor energy performance. This provides an opportunity for improvement in the following year.	The site has Energy goals, which are periodically reviewed. However, the goals are not communicated to all the site personnel, which limit the scope and awareness of the document. Along with the goals, a formal energy policy document with a structure to incorporate good energy practices will set the foundation strong. Site 7 can also focus on taking necessary actions after internal audits are conducted, offering incentives for energy efficiency actions, acquiring an Energy certification and developing a relationship with the local authorities on energy matters.

Feedback from EDF Climate Corps

Action Plan

Action Item	Proposed Dates		Actual Dates		Comments
	Start	Finish	Start	Finish	
Plan					
Do					
Check					
Act					

Grey indicates network score < global score - 0.5
Red indicates score < 2.0

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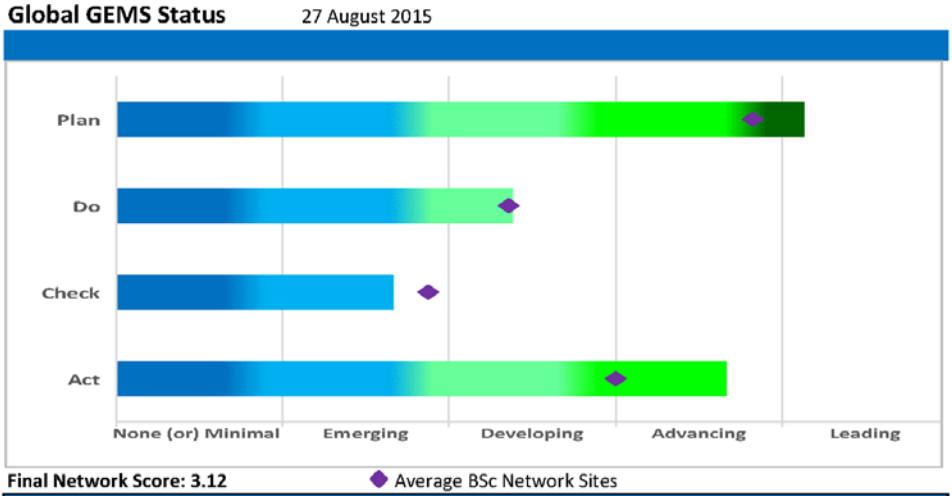
BSC GEMS EM3: Baseline Benchmark 2015

This score card displays, in the four main headings: Plan, Do, Check and Act; the comparative results from an energy management maturity model requirements applied to a multi-site entity with global prescense. Two points of view are presented in the graph, the averaged perspective of all the sites in the global network and the global energy management team. The scoring system ranges from 1.0 to 5.0 and the graph positions each of the evaluated aspects in one of the five maturity levels: None (or) Minimal, Emerging, Developing, Advancing and Leading. For details on how each was calculated, see the text beneath the graph for the main measured areas. To learn more click BSC GEMS EM3.

Global GEMS Status

27 August 2015



Final Network Score: 3.12

◆ Average BSc Network Sites

Legend					
	Network	Global		Network	Global
Plan	**3.83**	**4.13**	**Do**	**2.36**	**2.38**
GFUM	**4.07**	**4.34**	**Site Characterisation**	**2.27**	**2.00**
Existence	4.44	4.67	Energy Breakdown	2.56	2.33
Resources assigned	3.69	4.00	Energy Audits	1.44	1.67
			Energy Benchmarking	2.81	2.00
Site Profile & Network Profile	**4.00**	**4.50**	**Performance Evaluation**	**2.31**	**2.00**
Energy Share of OPEX	4.31	5.00	EnPI	2.31	2.00
Data Collection and Analysis	3.69	4.00	**Shared Learning / Dissemination**	**2.38**	**3.00**
			Information Sharing	3.38	4.67
			Energy Training	1.38	1.33
Best Practices/Demonstrator Sites	**3.00**	**3.00**	**Corporate Policy**	**2.63**	**2.67**
Information Level	3.00	3.00	Investment Assessments	2.63	2.67
Check	**1.88**	**1.67**	**Act**	**3.00**	**3.67**
Systematic DSS	**1.88**	**1.67**	**Management Evaluation & CI**	**3.00**	**3.67**
DSS	1.88	1.67	Sustainability Targets	3.00	3.67

Global Energy Management Team Comments

Strengths: *Plan* - GFUM.
Weaknesses: *Plan* - (Share of Opex) Minor gaps need to be addressed around the level of granularity for the Utilities Wheel of Spend on each site. *Do* - (Site Characterisation) Clear need for a global approach to Energy Audits. Gap between network and global team with respect to level of benchmarking.
Opportunities: *Do* - (SL/Dissemination) Clear need for global approach to Energy Training. Gap between network and global team with respect to information sharing. *Check* - (DSS) Clear need to provide a robust DSS for energy projects. *Act* - (Sustainability Targets) Gap between network and global team with respect to Global Sustainability targets.
Threats: Nothing specific, however maintaining visibility at a corporate level on energy and sustainability is a must.

Final Score = (3*Plan + Do + Check + Act)/6
Section scores average all questions not sub-section average

Grey indicates global score > network average + 0.5
Red indicates score < 2.0

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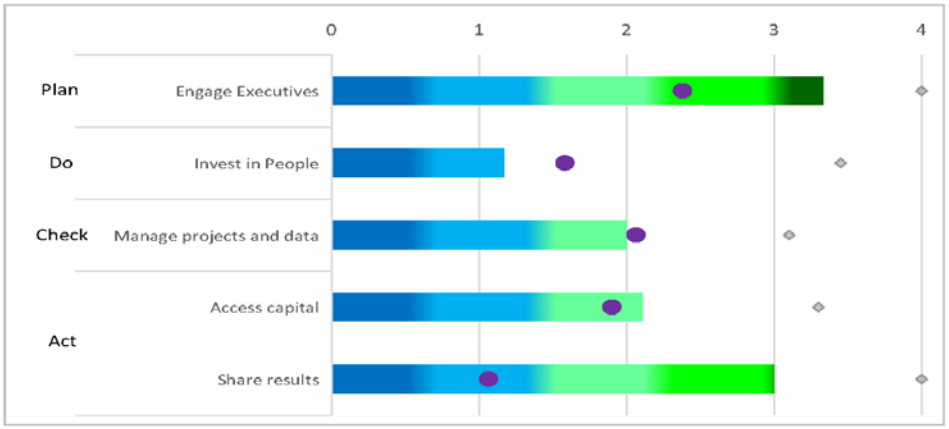
BSC GEMS EM3: Baseline and Benchmark 2015

Below are the results from the EDF Smart Energy Diagnostic. The graph displays both, the global energy management teams scores and the network average scores in five key capacities, with the highest score possible being a 4.0. Also displayed on the graph are the 90th percentile scores for the EDF Climate Corps organizations who completed the Smart Energy Diagnostic in 2014 (over 300 companies). For details on how your score was calculated, see the text beneath the graph, and if you'd like to learn more about the practices EDF Climate Corps has identified as leading, please view the complete EDF Smart Energy Diagnostic Rubric.

EDF Status

27 August 2015 EDF Global Energy Management Team Survey



Final Network Score: 1.79 ● Average BSc Network Sites ◇ 2014 Climate Coprs Cohort, 90th percentile

Legend					
	Network	Global		Network	Global
Plan	**2.38**	**3.33**	**Do**	**1.58**	**1.17**
Engage Executives	**2.38**	**3.33**	**Invest in People**	**1.58**	**1.17**
Ambition and goals	2.38	3.33	Accountability	1.31	1.67
			Expertise	2.31	1.67
			Collaboration	0.88	1.00
			Engagement	1.81	0.33
Check	**2.06**	**2.00**	**Act**	**1.69**	**2.34**
Manage projects and data	**2.06**	**2.00**	**Access capital**	**1.90**	**2.11**
Identifying projects	2.44	2.67	Funding	1.81	1.67
Implementing projects	2.13	2.67	Dependability	2.44	3.00
Data Collection	1.88	1.33	Accessibility	1.44	1.67
Measuring Savings	1.75	1.33	**Share results**	**1.06**	**3.00**
Decisions	2.13	2.00	Reporting	1.06	3.00

Global Energy Management Team Comments

This is a great benchmark for BSC against a database of our peers and competitors. Clearly we are beginning out Energy Maturity journey but with a strong foundation in place we can improve quickly.
Focus areas include investment in people (all aspects – esp engagement) and managing projects & data (esp data collection & measuring savings). Access to funding is deemed difficult.
Gaps need to be closed on the alignment between the network and the global team on Executive Engagement & Sharing Results.

Grey indicates network score < global score - 0.5
Red indicates score < 2.0