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Predicting the Quantifiable Impacts of ISO 50001 on Climate Change Mitigation

Aimee McKane[a], Peter Therkelsen[a], Anna Scodel[a], Prakash Rao[a], Arian Aghajanzadeh[a], Simon Hirzel[b], Ruiqin Zhang[c], Richard Prem[d], Alberto Fossa[e], Ana M. Lazarevska[f], Marco Matteini[g], Bettina Schreck[g], Fabian Allard[h], Noé Villegal Alcántar[i], Karel Steyn[j], Ertaç Hürdoğan[k], Thomas Björkman[l], and John O'Sullivan[m]

[a] Lawrence Berkeley National Laboratory, One Cyclotron Road, Berkeley, CA 94720, USA

[b] Fraunhofer Institute for Systems and Innovation Research ISI, Breslauer Strasse 48, 76139 Karlsruhe, Germany

[c] Zhengzhou University, No. 100 Science Avenue, Zhengzhou 450001, China

[d] Prem Consulting, Josefstaedter Strasse, 51/1/30, 1080 Vienna, Austria

[e] MDJ Consulting, Avenia Vereador José Diniz, 3720 - 7o andar, São Paulo, Brazil

[f] Ss. Cyril and Methodius University, Faculty of Mechanical Engineering, ul. Rugjer Boshkovikj, bb, Skopje, Macedonia

[g] United Nations Industrial Development Organization, Vienna International Centre, P.O. Box 300, A-1400, Vienna, Austria

[h] Natural Resources Canada, 580 Booth Street, Ottawa, Ontario, Canada

[i] National Commission for the Efficient Energy Use, Av. Revolución 1877, Piso 8, Barrio Loreto, Álvaro Obregón, 01090, Ciudad de México, Mexico

[j] Eskom, PO Box 1091, Johannesburg, 2001, South Africa

[k] Osmaniye Korkut Ata University, 80000 Osmaniye, Turkey

[l] Swedish Energy Agency, Kungsgatan 43 Eskilstuna, Rosenlundsgatan 9, Stockholm, Sweden

[m] Sustainable Energy Authority of Ireland, Wilton Park House, Wilton Place, Dublin 2 D02 T228

Energy Technologies Area

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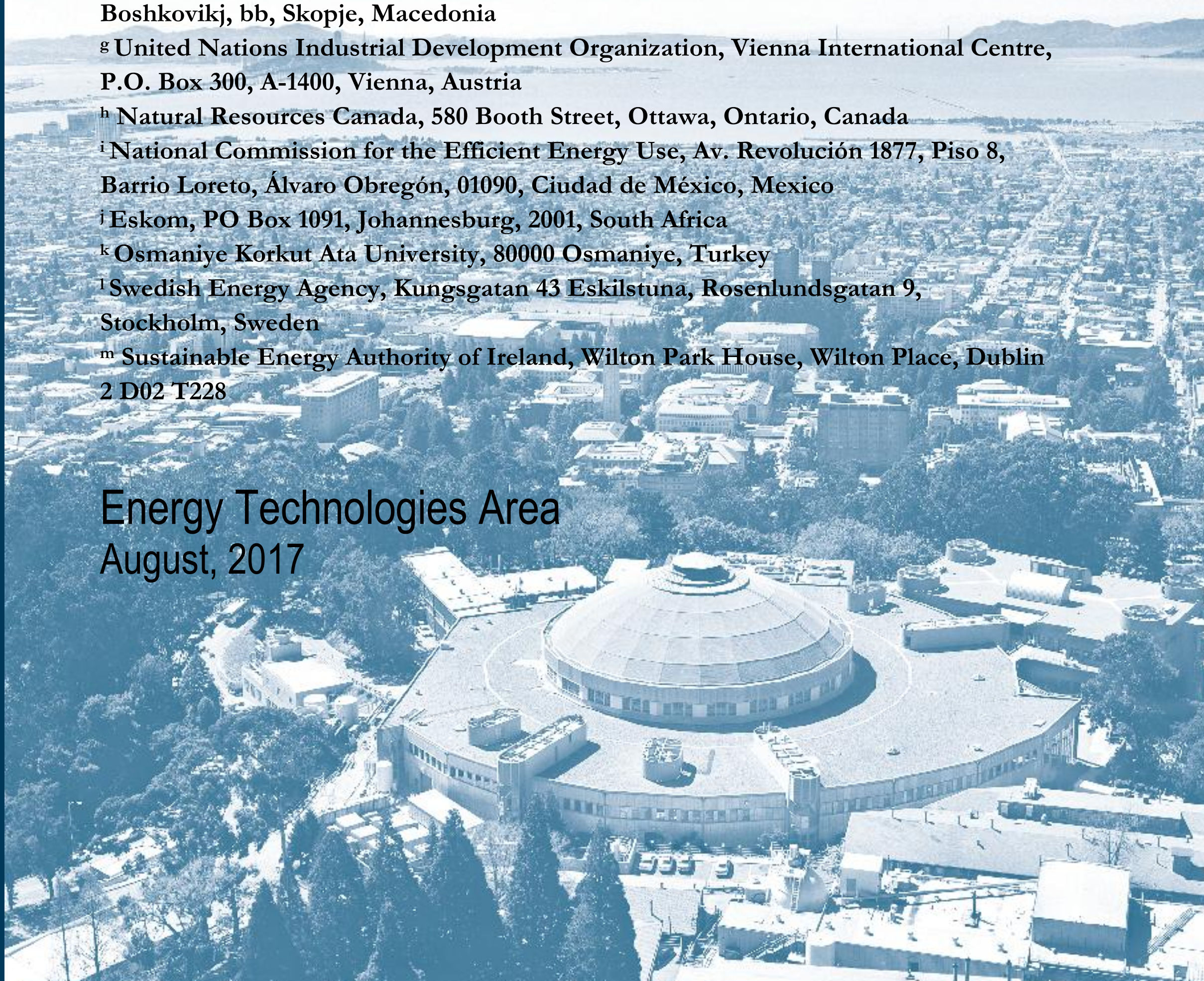

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Abstract

Energy consumption in the industrial and commercial (service) sectors accounts for nearly 40% of global greenhouse gas emissions. Reducing this energy consumption will be critical for countries to achieve their national greenhouse gas reduction commitments. The ISO 50001-Energy management standard provides a continual improvement framework for organizations to reduce their consumption. Several national policies already support ISO 50001; however, there is no transparent, consistent process to estimate the potential impacts of its implementation.

This paper presents the ISO 50001 Impacts Methodology, an internationally-developed methodology to calculate these impacts at a national, regional, or global scale suitable for use by policymakers. The recently-formed ISO 50001 Global Impacts Research Network provides a forum for policymakers to refine and encourage use of the methodology.

Using this methodology, a scenario with 50% of projected global industrial and service sector energy consumption under ISO 50001 management by 2030 would generate cumulative primary energy savings of approximately 105 EJ, cost savings of nearly US $700 billion (discounted to 2016 net present value), and 6500 million metric tons (Mt) of avoided CO_2 emissions. The avoided annual CO_2 emissions in 2030 alone are equivalent to removing 210 million passenger vehicles from the road.

Highlights
Present a methodology to estimate global or national impacts of ISO 50001 uptake
Policymakers can use this methodology in developing national or regional programs
Methodology applies to global energy consumption in industrial and service sectors
Estimates of 105 EJ of *cumulative primary* energy saving from ISO 50001 by 2030

Keywords
Climate change mitigation; Energy management; ISO 50001; Savings methodology; Energy savings; Greenhouse gas emissions

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Abbreviations

ATPEC	Adjusted total projected energy consumption
CES	Cumulative energy savings
CSI%	Continual savings improvement percentage
CIES	Continual improvement of energy savings
ECUM	Energy consumption under management
ES	Energy savings
k	Steepness of the logistic function (function growth rate)
L	Logistic function maximum value (upper asymptote)
L_0	Logistic function initial value (lower asymptote)
NAES	New annual energy savings
PV	Present value
r	Interest rate based on a 10 year US treasury bond yield rate
$t_{current}$	Present year to which the annual savings are being discounted
t	The year at which the cost savings are observed
t_{pmg}	The year at which the logistic function reaches a point of maximum growth
TAES	Total annual energy savings
TPEC	Total projected energy consumption
TNAES	Total new annual energy savings

1 Introduction

For the 197 countries who are convention parties to the United Nations Conference on Climate Change 2015 Paris Agreement, achieving their GHG reduction targets will require an unprecedented focus on effective policies, international coordination, and engagement with key stakeholders, especially in the private sector. Because energy consumption in the industrial and commercial sectors accounts for nearly 40% of global GHG emissions (Fischedick et al., 2014; Lucon et al., 2014), reducing energy consumption in these sectors is critical for countries working to achieve their GHG reduction targets. Although the energy savings potential in the industrial and commercial sectors is significant, barriers remain to achieving these savings. According to the Intergovernmental Panel on Climate Change, "a lack of human and institutional capacities to encourage management decisions is a primary barrier for energy efficiency that must be removed for the industrial sector to realize its mitigation potential" (Fischedick et al., 2014).

The systematic management of energy has been identified as a pathway to overcome a number of these barriers and improve energy efficiency in organizations while maintaining productivity (EMWG, 2014). The International Organization for Standardization (ISO) 50001 - *Energy management systems – Requirements with guidance for use* provides a continual improvement framework to guide organizations in making energy performance improvement an ongoing part of normal business operations, rather than focusing on individual efficiency projects (McKane et al., 2009). Through its dual emphasis on an energy management system (EnMS) and continual improvement of energy performance, ISO 50001 assists organizations in reducing industrial and commercial energy consumption, managing energy costs, and avoiding GHG emissions. Therkelsen et al. (2015) have shown that the implementation of an ISO 50001-certified EnMS results in more than four times the energy savings achieved under a business as usual scenario, with a payback of under 1.5 years for medium to large industrial facilities.

Organizations around the world are implementing ISO 50001 on their own initiative and in response to national and regional policies and programs. Facilities that implement ISO 50001 can choose to demonstrate their conformance to the standard through validation by an external certification body. An ISO-maintained database of these certifications reports that nearly 12000 ISO 50001 certificates were issued worldwide in 2015, up from nearly 7000 in 2014 (ISO, 2015). While the number of ISO 50001 certificates issued continues to increase, accelerated uptake is needed to significantly impact global GHG emissions. To support this acceleration, policymakers need to be able to transparently assign, evaluate, and communicate the value of ISO 50001 adoption on a national, regional, and global scale. In addition, policymakers would greatly benefit from opportunities to share information on the relative efficacy of ISO 50001-enabling policies in a range of regulatory contexts.

The Energy Management Working Group (EMWG) of the Clean Energy Ministerial provides an international forum for member governments to collaborate on activities to accelerate broad use of EnMS in industry and commercial buildings worldwide (EMWG, 2016a). The EMWG identified the need for an internationally-developed, transparent, and adaptable methodology to estimate the impacts of ISO 50001 and subsequently established the ISO 50001 Global Impacts Research Network (Impacts Network). Membership of the Impacts Network includes international academics, researchers, and policymakers, who collectively are tasked with providing input on the development of the methodology and facilitating discussion of policy drivers for energy management.

This paper describes the ISO 50001 Impacts Methodology as set forth in the ISO 50001 Impacts Estimator Tool (IET 50001) and presents estimates of the potential global energy, energy cost, and carbon dioxide (CO_2) emissions savings associated with ISO 50001 uptake. The IET 50001 software is designed to help global policymakers estimate the impact of implementing ISO 50001 in a country or region. The Impacts Network has provided comments and expert guidance in shaping and refining the methodology presented in this paper. To provide a policy context, the Impacts Network experts have also contributed several examples of national and regional ISO 50001 implementation plans, actions, and impacts, which are included in Appendix A.

2 Background

Reducing energy consumption in the industrial and commercial sectors presents a significant opportunity for countries to achieve the GHG reduction targets outlined in the COP21 INDCs. The industrial sector[1] contributes 30% of total GHG emissions, of which 85% are CO_2 (Fischedick et al., 2014). Based on Lucon et al. (2014), the commercial sector accounts for 7% of global GHG emissions. The bulk of commercial-sector emissions are indirect CO_2 emissions from the consumption of electricity in buildings.

In recent decades there have been improvements in energy intensity (a measure of the energy used per unit of output) in the industrial sector, but the progress has been more than offset by growth in production (IIP, 2012). Looking forward, energy demand in both the industrial and service sectors is expected to steadily grow (EIA, 2013; Fischedick et al., 2014), making it particularly important for governments and businesses to work towards achieving greater improvements in energy performance to limit climate impacts.

Improved energy efficiency has been identified as a low-cost option to reduce CO_2 emissions from organizations while maintaining or improving productivity levels (IEA, 2015a; UNIDO, 2011). Substantial energy savings are available in the industrial and service sectors from both technological and operational improvements (UNIDO, 2011). Cost savings potentials in the service sector from high-performance envelope and higher-efficiency equipment are between 35-50%, and retrofits can achieve 25-70% savings in total energy use (Lucon et al., 2014).

[1] For the purposes of this paper the industrial sector includes manufacturing, mining, and construction.

Although best available technologies are approaching technical limits for some sectors, there remain many energy-efficiency opportunities in optimizing the operation of industrial processes and the configuration and operation of industrial and service sector systems, especially for less energy-intensive industries. For example, motor-driven equipment consumes about 60% of electricity in manufacturing, and while replacing motors can deliver between 2% and 5% in energy savings, optimizing the motor system, made up of multiple components, can achieve savings between 20-30% (UNIDO, 2010). The emissions mitigation potential associated with industrial efficiency improvements is higher in developing countries than in developed ones (UNIDO, 2011), offering substantial opportunity to incorporate energy efficiency improvements into new facility design and to sustain these efficiencies through effective energy management.

Despite the significant potential for efficiency improvements and emissions reductions, barriers continue to limit uptake of these measures including: management focus on production rather than energy; lack of energy use and consumption data; lack of understanding of financial and other non-energy benefits from reducing energy use; a shortage of technical skills for identifying, developing, and implementing energy efficiency measures; a disconnect between capital costs and operating costs, and limited upfront capital (DOE, 2015; McKane et al., 2009; Sorrell et al., 2011). Energy management systems provide an organizational structure for overcoming these barriers.

Table 1: National Policies in Support of Industrial Energy Management and Energy Efficiency

	IN-Informational Programs; **TP**-Tax policies (incentives and/or penalties); **REG**-Regulations for energy efficiency/energy management; **TSA**-Target-setting Agreements w/ industry; **FEII**-Focus on Energy-Intensive Industries; **EnMS**-Energy Management Standard; **SA**-Subsidized Energy Assessments or Audits; **FEEM**-Financial assistance for Energy Efficiency/EnMS Implementation; **TREM**-Training for Energy Managers; **RP**-Recognition Program									
Country	**IN**	**TP**	**REG**	**TSA**	**FEII**	**EnMS**	**SA**	**FEEM**	**TREM**	**RP**
Austria			✓			✓				
Brazil	✓		✓			✓	✓			
Canada	✓	✓		✓	✓	✓	✓	✓	✓	✓
China	✓		✓	✓	✓	✓	✓	✓	✓	✓
Colombia	✓					✓	✓		✓	✓
Denmark	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Egypt	✓							✓	pend	
France	✓	✓	✓		✓	✓				✓
Germany	✓	✓	✓		✓	✓		✓		✓
India	✓		✓	✓	✓	✓			✓	✓
Ireland	✓	✓	✓	✓(VA, no negotiated targets)	✓	✓	✓		✓	✓
Japan	✓	✓	✓		✓	✓	✓	✓	✓	✓
Korea	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Macedonia	✓				✓				✓	
Mexico	✓					✓			✓	
Netherlands	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
South Africa	✓	✓	pend	✓	✓	✓			✓	
Sweden	✓	✓	✓	✓	✓	✓	✓		✓	✓
Thailand	✓	✓	✓		✓	✓	✓		pend	✓
Turkey	✓					✓		✓		
United Kingdom	✓	✓	✓	✓	✓	✓	✓			✓
United States	✓			✓	✓	✓	✓		✓	✓
Source: Updated by authors from Global Energy Assessment: Toward a Sustainable Future 2012										

3 ISO 50001 – Energy Management System Standard

Energy management has been identified as a key component of achieving energy savings in the industrial and commercial sectors (UNIDO, 2011; Worrell, 2011), which means it is a key component of achieving GHG emissions reductions. A key outcome of ISO 50001 implementation is continual improvement in energy performance. Energy performance is defined by ISO 50001:2011 as the, "measurable results related to energy efficiency, energy use, and energy consumption." Backlund, et. al. (2012) argue that estimates of the potential for energy efficiency in organizations would be higher if they considered energy management practices, as technology-focused energy efficiency actions alone are unlikely to achieve their full potential without maintenance and continuous monitoring. Estimates of the energy savings potential for organizations that adopt an EnMS range from 10-40% (Ahmed et al., 2010; Duarte and Acker, 2011; EMWG, 2014; IIP, 2012).

ISO 50001 is a voluntary, internationally-developed standard for energy management systems that offers a flexible framework for organizations and facilities to integrate energy efficiency into their management practices. It establishes requirements for an EnMS and builds on previous ISO management standards like 9001 (quality management) and 14001 (environmental management) that use a continuous improvement model to improve quality and safety in organizations worldwide. A portfolio of related standards has been developed to support and encourage the implementation of ISO 50001 and to assist in the quantification of resulting energy performance improvements.

ISO 50001 can be applied in any sector and provides organizations with an internationally-accepted structure for: improving their understanding of current energy use and consumption, identifying capital and operational energy efficiency opportunities, providing a business context for implementation decisions, and evaluating the post-implementation results. Key elements include: establishing an energy policy, energy management team, and a baseline of organizational use; identifying energy performance indicators, setting targets, and incorporating controls and procedures to address energy use; and measuring and documenting energy performance and reporting to management.

The business context and the management support required for implementation of ISO 50001 can help overcome a number of the most common barriers to improving energy performance in organizations. The EnMS integrates the management of energy into daily business practices to help organizations identify, implement, and measure energy saving opportunities. Unlike traditional project-based energy efficiency actions, the EnMS approach emphasizes cultural changes in business processes rather than focusing solely on individual projects. A well-designed EnMS allows organizations to actively manage energy and reduce cost without negatively impacting production or operations and document savings. This enables organizations to achieve sustained and persistent system-wide improvements (McKane et al., 2009).

4 Global ISO 50001 Uptake and Supporting Policies

ISO 50001 has been widely adopted as a national and regional standard. A number of national policies and programs have fostered uptake and effective implementation of ISO 50001. Public programs in support of EnMS implementation help organizations overcome barriers to industrial and commercial efficiency with tax incentives, regulatory mechanisms, recognition programs, information provision, training, workforce development, and technical tools and assistance (Reinaud and Goldberg, 2014; UNIDO, 2008).

The majority of ISO 50001 certificates issued in 2015, the most recent ISO data available, were in Germany, followed by the United Kingdom, Spain, Italy, and India. The five countries with the most growth in the number of certificates between 2014 and 2015 were Germany, France, Spain, India, and China (ISO, 2015). The number of certifications continues to increase substantially as large international companies seek certification across their organizations (e.g., Hilton Worldwide, which has certified more than 4200 properties to ISO 50001 in 2014).

Regional and national programs to support industrial energy efficiency can be mandatory or voluntary. They will vary in terms of the offerings and incentives. Table 1 provides a comparison of the characteristics of some public-sector programs and policy mechanisms in support of improving energy efficiency and EnMS in the industrial sector. For more detailed descriptions of national programs submitted by Impacts Network experts, see Appendix A.

While some countries have been building policies for several years and now operate mature programs, others are in the early stages of program development. In both cases, policymakers have some ability to monitor progress and impact through ISO-50001 certification numbers, organizational reporting on energy savings, and other verification mechanisms. What has been lacking is a consistent and transparent mechanism for policymakers worldwide to estimate the savings potential from ISO 50001 implementation.

As the heart of ISO 50001 is a non-tangible culture-changing business practice. A key outcome of this culture change is improved decision making relative to energy efficiency project implementation and technology adoption. Because of this, estimating the energy and CO_2 savings impact of the ISO 50001 continual improvement approach at the national or regional level is more complex than estimating the impact of technology upgrades such as lighting. Further, it has been difficult to monitor how energy efficiency policies contribute towards meeting national energy and climate change mitigation targets (Schreck, 2011). Establishing the value of ISO 50001 uptake can help inform policymaking, reduce the transaction costs of establishing EnMS programs (Tanaka, 2011), and provide supporting documentation for program development.

A number of factors make aggregation of ISO 50001 impacts challenging. At the organizational or facility level, energy performance improvement is measured using organization-specific metrics. Some countries focus their industrial energy efficiency programs on reducing electricity consumption, while others consider energy consumption across the full range of energy types. Differences in how national and regional implementation programs account for energy performance improvement, report savings, and record uptake can further complicate aggregation of impacts.

A globally accepted methodology to determine the potential impact of ISO 50001 on a national and global scale has been developed. When applied by country and regional-level policy makers, the methodology can facilitate the development of baselines and targets for ISO 50001 adoption. The use of the methodology by multiple countries can enable harmonization of savings estimates, comparison of impacts, and knowledge sharing on the efficacy of different program implementation schemes.

5 Methodology

The ISO 50001 Impacts Methodology has been established to assist policymakers in determining the impact of industrial and commercial (service) sector ISO 50001 implementation on a regional, national, or global scale. The methodology is detailed in this paper and has been embodied as software in the ISO 50001 Impacts Estimator Tool (IET 50001) (EMWG, 2016b). To be consistent with IEA data sources, the methodology description that follows and the IET 50001 use the term “service” to describe the commercial sector. For the purpose of this paper, these terms should be considered to be equivalent.

The ISO 50001 Impacts Methodology was designed based on the following criteria: the use of accepted, existing data sources (e.g., International Energy Agency); the use of transparent, testable assumptions; and the ability for users to customize inputs. Methodology users must identify a region of interest, gather relevant input data including projected energy consumption on a delivered basis and carbon emission factors for various energy types, establish a projection of ISO 50001 uptake for the time period of interest, and select what level of annual savings will be realized from ISO 50001 implementation. These inputs are used to determine the amount of energy under the management of an ISO 50001 EnMS and the resulting energy, energy cost, and CO_2 emissions savings. Energy cost and CO_2 emissions savings are determined based upon calculated energy savings. ISO 50001 Impacts Methodology users can aggregate results generated by applying the methodology for multiple regions or economic subsectors. For example; the methodology could be used for each country or industrial/service subsector (e.g., glass, pulp and paper, hospitality, and educational) within the country, and the results aggregated across multiple countries or subsectors within a geographic area.

5.1 Determining an ISO 50001 Uptake Function

Energy savings resulting from ISO 50001 uptake are calculated based upon user-supplied projections of energy consumption for the region of interest. The ISO 50001 Impacts Methodology assumes that only a fraction of the total projected energy consumption will be under the management of an ISO 50001 EnMS and that ISO 50001 uptake will be non-linear over the time period of interest. This latter assumption is based upon evidence from uptake of other ISO management standards such as ISO 9001 and ISO 14001 both globally and in individual countries. The ISO 50001 adoption rate is assumed to grow slowly initially with early adopters implementing the EnMS. However, through the experiences of the early adopters, best practices and implementation resources will become available and policies will begin to form around ISO 50001. During this period, ISO 50001 adoption will grow exponentially up until a period of near-saturation. Beyond this point, the adoption rate will decline until an ultimate maximum uptake level is reached. This results in an individual ISO 50001-uptake percentage for each year of the adoption. A logistic function is used to model this non-linear uptake of ISO 50001. The general form a logistic function is shown in Figure 1 and detailed in Equation 1.

Equation 1 $$\text{ISO 50001 uptake } \%_t = L_0 + \frac{L - L_0}{1 + e^{-k(t - t_{pmg})}}$$

Where:

- L_0 is the initial year uptake value of ISO 50001 for the time period of interest,
- L is the final year uptake value of ISO 50001 for the time period of interest,
- t_{pmg} is the year at which the logistic function reaches a point of maximum growth,
- k is a factor to adjust the rate of uptake.

L_0 and L are values, expressed as percentages, that represent the fraction of projected energy consumption under the management of an ISO 50001 EnMS at the start and end points of the analysis. This percentage is established as the amount of energy under the management of an ISO 50001 EnMS divided by the total projected energy consumption (TPEC) for the region of interest.

An appropriate value for L_0 may be 0% if 2011, the year ISO 50001 was first published, is selected as the initial year. The selection of a value for L may be based on a number of factors, including a determination of economic, technical, or market potential for ISO 50001 within a region. The rationale behind the selection of L and L_0 values should be documented to maintain the transparent nature of the methodology and its use.

To determine the shape of the uptake function, users must determine the values of t_{pmg} and k. One method to establish these values is to use historical certification values for ISO 9001, ISO 14001, or other ISO management systems. An iterative process can be used to determine values for t_{pmg} and k that provide the best fit for the historical data, which are subsequently used to model uptake of ISO 50001. Historic certification data should be evaluated and adjusted for non-routine events such as economic downturns as well as the absence of data. Methodology users should be aware that the number of certificates issued for these other standards, or even ISO 50001, does not directly correlate to the amount of energy consumption under the management of an ISO 50001

EnMS. [2]However, the use of certification values to fit an uptake model can approximate the uptake rate of ISO 50001.

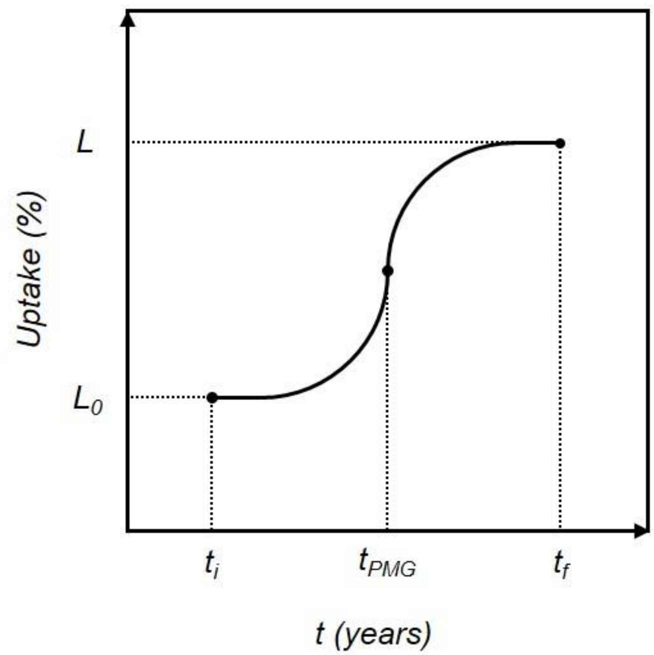

FIGURE 1: Illustration of a Logistic Function and Associated Nomenclature

Having determined L_0, L, t_{pmg}, and k values, a logistic function describing the uptake of ISO 50001 expressed as percent of TPEC can be established.

5.2 Calculating Energy Savings

The ISO 50001 Impacts Methodology separately determines two types of energy savings from ISO 50001: savings that result from the first-year energy consumption comes under the management of an ISO 50001 EnMS, and additional energy savings in subsequent years resulting from the continual improvement foundation of ISO 50001. Continual improvement energy savings are calculated for energy consumption that has already come under the management of an ISO 50001 EnMS in previous years.

Energy savings should be calculated on a primary energy basis to reflect savings within the region of interest. The default assumption is that projected energy consumption values used as inputs are supplied on a delivered energy basis. The software embodiment of this methodology, the IET 50001 Tool, uses offsite electricity and steam generation multipliers (supplied by the user) to automatically convert delivered energy consumption to primary energy consumption prior to the calculation of energy savings. However, if the tool user would like to enter projected energy consumption values on a primary basis,

[2] Due to business and other considerations, not all ISO 50001-compliant organizations choose to become certified. Since reliable data are not available concerning the fraction these organizations represent of all ISO 50001-compliant organizations, this analysis uses available data on certified organizations.

they also need to set offsite electricity and steam generation multipliers to the value of one. Regardless of which method is used, the final numbers presented in the results section will be calculated on a primary energy basis.

5.2.1 Calculating Energy Savings for the Initial Year

Before calculating annual energy savings for the initial year (t = 0), initial year energy consumption under management (ECUM) must be established by taking the product of initial year TPEC and initial year ISO 50001 uptake percentage for both the industrial and service sectors as shown in Equation 2.

Equation 2 $$\text{ECUM}_{t=0} = \text{TPEC}_{t=0} \times \text{ISO 50001 uptake \%}_{t=0}$$

New annual energy savings (NAES) attributable to ISO 50001 for the initial year are then calculated as shown in Equation 3 as the product of industrial and service sector ECUM and initial year percentage of energy savings attributable to ISO 50001 as determined in Section 5.1.

Equation 3 $$\text{NAES}_t = \text{ECUM}_t \times \text{\% of ES attributable to ISO 50001}$$

Because this is the initial year, the continual improvement in energy savings from previous years is not considered. Therefore, Total New Annual Energy Savings (TNAES) for the first year equals the NAES. However, energy savings due to continual improvement will be a consideration in subsequent years.

5.2.2 Calculating Energy Savings for Subsequent Years

TPEC values are commonly available from government or other reports and typically do not account for the projected impact of ISO 50001. Because ISO 50001 supports continual improvement, this methodology makes adjustments to the projected energy consumption values to account for the reductions in energy consumption associated with ISO 50001-related energy savings sustained from previous years.
Adjusted total projected energy consumption (ATPEC) is calculated for years after the initial year by subtracting energy savings calculated for the previous year from the current year unadjusted TPEC value as shown in Equation 4.

Equation 4 $$\text{ATPEC}_t = \text{TPEC}_t - \sum_{n=1}^{t-1} \text{TNAES}_n$$

The ATPEC for a given year is then used along with the ISO 50001 uptake % for that same year to calculate the ECUM per Equation 5.

Equation 5 $$\text{ECUM}_t = \text{ATPEC}_t \times (\text{ISO 50001 uptake \%}_t - \text{ISO 50001 uptake \%}_{t-1})$$

Continual improvement of energy performance is a foundation of ISO 50001. Continual improvement of energy performance indicates that energy savings from previous years will be maintained and built upon, ever increasing the total energy savings. The ISO 50001 Impacts Methodology takes this into account by calculating continual improvement energy savings (CIES) for years subsequent to the initial year by applying a continual savings improvement percentage value, CSI%. To account for continual energy performance improvement, energy consumption that comes under the management of an ISO 50001 EnMS each year must be accounted for separately. Equation 6 details how CIES is calculated.

Equation 6 $$\mathrm{CIES}_t = \mathrm{CSI\%} \times \sum_{n=1}^{t-1}(ECUM_n - NAES_n - CIES_n)$$

TNAES (Total New Annual Energy Savings) for a given year after the initial year as shown in Equation 7 is calculated as the product of current year ECUM and the percentage of energy savings attributable to ISO 50001 plus CIES for the current year.

Equation 7 $$\mathrm{TNAES}_t = \mathrm{NAES}_t + \mathrm{CIES}_t$$

Figure 2 graphically represents the relationship of multiple years Energy Consumption Under Management (ECUM), New Annual Energy Savings (NAES), Continual Improvement of Energy Savings (CIES), Total Projected Energy Consumption (TPEC), and Adjusted Total Projected Energy Consumption (ATPEC).

Figure 3 illustrate NAES for the first two years, showing how CIES from the year one ECUM is included in determining year two NAES. Total Annual Energy Savings (TAES) are calculated as the summation of each year's Total New Annual Energy Savings (TNAES) (Equation 8). TAES is also graphically represented in Figure 3.

Equation 8 $$\mathrm{TAES}_t = \sum_{n=1}^{t} \mathrm{TNAES}_n$$

Finally, the cumulative energy savings (CES) is calculated as shown in Equation 9.

Equation 9 $$\mathrm{CES}_t = \sum_{n=1}^{t} \mathrm{TAES}_n$$

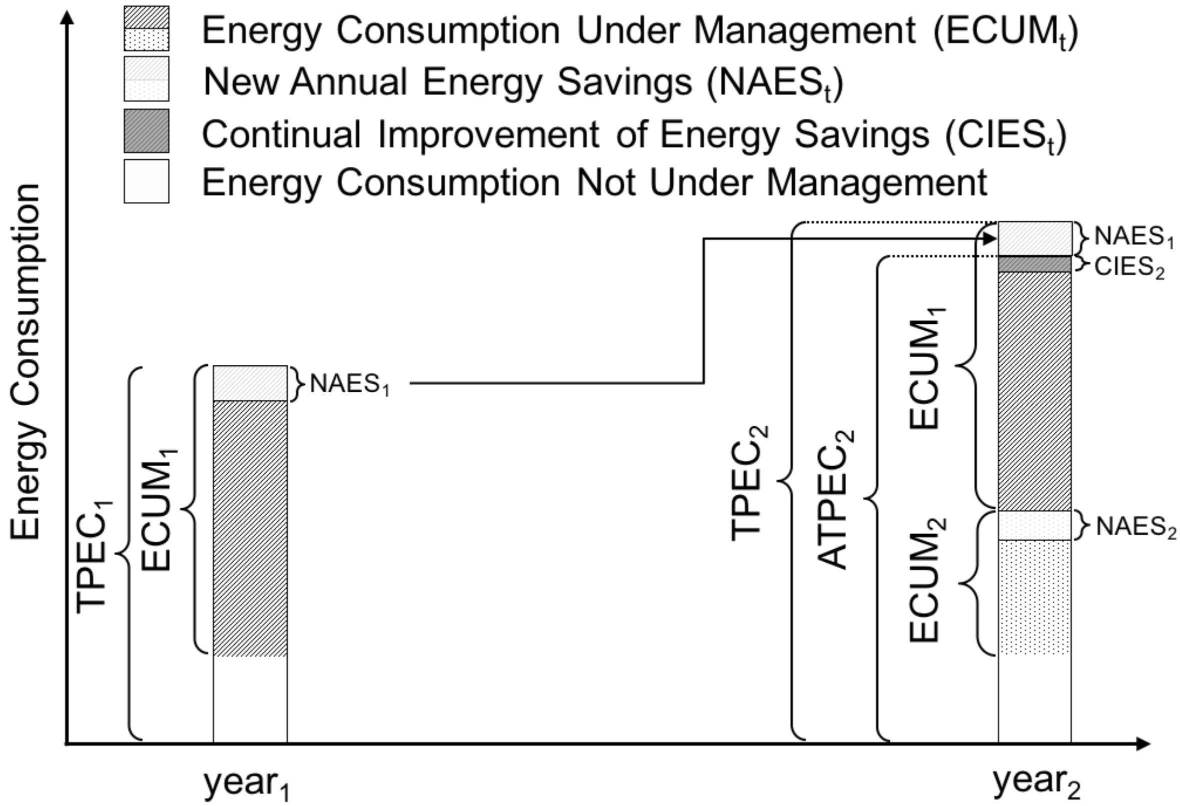

FIGURE 2: Graphical representation of the Energy Consumption Under Management (ECUM), New Annual Energy Savings (NAES), Continual Improvement of Energy Savings (CIES), Total Projected Energy Consumption (TPEC), and Adjusted Total Projected Energy Consumption (ATPEC) for Years One and Two

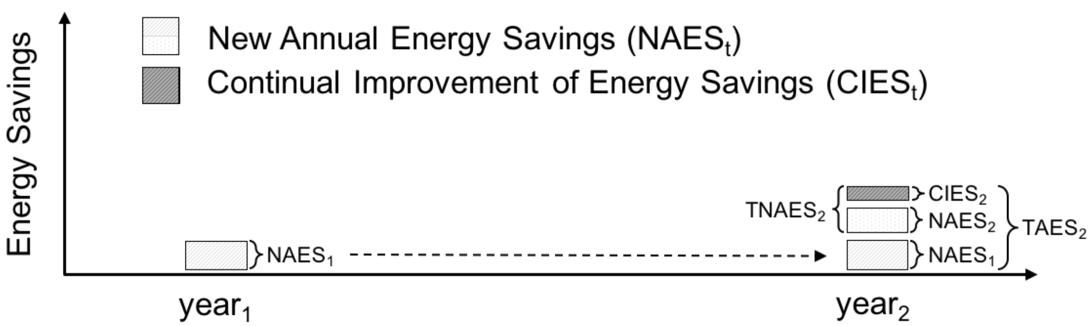

FIGURE 3: Graphical representation of the New Annual Energy Savings (NAES), Continual Improvement of Energy Savings (CIES), Total Annual Energy Savings (TAES), and Total New Annual Energy Savings (TNAES) for Years One and Two

5.3 Calculating Energy Cost Savings

Energy cost savings are calculated for the current year as well as corrected to account for the present value of the energy cost. Cost savings for a given year are calculated as the product of NAES for the given year and a blended energy cost value. The blended energy cost value is the average of the energy costs for each energy source weighted by its share of total energy consumption. The cost savings for each year can be discounted to present value. Equation 10 can be used to determine present value of annual cost savings.

Equation 10 $$\text{PV} = \frac{\text{Annual Cost Saving for year } t}{(1+r)^{(t-t_{current})}}$$

5.4 Calculating CO_2 Savings

CO_2 emissions savings for a given year are calculated as the product of TAES for that year and an appropriate CO_2 emissions rate for the region. CO_2 emission rates are typically reported on a delivered basis, such as metric tons of CO_2 per kWh consumed. For energy types that ordinarily do not include a primary to delivered multiplier, such as natural gas or diesel fuel, this issue will not be of concern. However, for energy types that do commonly include primary to delivered multipliers such as delivered electricity and steam, care should be taken to convert calculated energy savings from primary to delivered prior to calculating CO_2 emissions values for these energy types.

5.5 Cumulative Savings from Individual Years

Energy, energy cost, and CO_2 emission savings calculated for individual years can be accumulated to reflect savings over time. Cumulative savings are calculated as the summation of savings for each year of interest.

5.6 Summary of ISO 50001 Impacts Methodology

Table 2 provides a summary of the ISO 50001 Impacts Methodology as defined by the inputs and outputs used for each step of the methodology. The table also includes reference to the appropriate section number of this paper.

Table 2: Summary of ISO 50001 Impacts Methodology as Defined by Outputs and Inputs

Output	Description	Input, from other steps	Input, user defined	Where it is used next
ISO 50001 uptake $\%_t$	ISO 50001 uptake across all years	-	L_0, L, t_{pmg}, k,	$ECUM_0$, $ECUM_t$
$ECUM_0$	Energy consumption under management for year 0	$TPEC_0$, ISO 50001 uptake $\%_0$	Total energy consumption in sector(s) of interest in year 0	$NAES_t$, $CIES_t$
$NAES_t$	New annual energy savings for year t	$ECUM_t$	% of ES attributable to ISO 50001	$TNAES_1$, $CIES_t$, $TAES_t$, Annual cost savings for year t
$TNAES_1$	Total new annual energy savings for year 1	$NAES_1$	-	$ATPEC_t$
$ATPEC_t$	Adjusted total projected energy consumption in year t	$TNAES_n$	$TPEC_t$	$ECUM_t$
$ECUM_t$	Energy consumption under management of an ISO 50001 EnMS in year t	$ATPEC_t$, ISO 50001 % uptake $\%_t$, ISO 50001 % uptake $\%_{t-1}$	-	$CIES_t$, $TNAES_t$
$CIES_t$	Continual Improvement in Energy Savings for year t	CSI% $\sum_{n=1}^{t-1} \text{ECUM}_n$ $\sum_{n=1}^{t-1} \text{NAES}_n$ $\sum_{n=1}^{t-1} \text{CIES}_n$	-	$TNAES_t$,
$TNAES_t$	Total new annual energy savings for year t	$ECUM_t$ $CIES_t$	% of ES attributable to ISO 50001	$TNAES_t$
$TAES_t$	Total new energy savings for year t	$NAES_n$	-	CES_t
CES_t	Cumulative energy savings for year t	$TAES_t$	-	-
Annual cost savings for year t	Cost savings for year t	$NAES_t$	Energy cost value (blended)	PV
PV	Present value for year t	Annual cost savings for year t	r	-
CO_2 savings for year t	CO_2 savings for year t	$TAES_t$	CO_2 emissions rate (blended)	-

6 Data

Using IET 50001, the authors have developed an initial estimate of the global impact of ISO 50001 implementation based upon the following assumptions:

- Initial year (t = 0) is 2011, the year ISO 50001 was first published.
- Uptake of ISO 50001 that results in 50% of projected global industrial and service sector energy consumption under ISO 50001 management by 2030 (L = 50%). The choice of 50% uptake in 2030 is designed to illustrate the potential impact of ISO 50001 EnMS on global energy consumption and emissions, although actual uptake is uncertain in the absence of globally consistent policy drivers.
- Industrial sector uptake of ISO 50001 follows a logistic function form with L_0 = 0%, L = 50%, t_{pmg} = 14 years, and k = 0.30. Based upon global historic ISO 14001 uptake in the industrial sector.
- Service sector uptake of ISO 50001 follows a logistic function form with L_0 = 0%, L = 50%, t_{pmg} = 9 years, and k = 0.65. Based upon global historic ISO 14001 uptake in the service sector.
- 5% energy savings in the first year energy comes under the management of ISO 50001. Based upon minimum requirements and observed results of the U.S. Department of Energy Superior Energy Performance program (Therkelsen et al., 2015).
- Continual energy savings of an additional 1% per year are realized. Based upon minimum requirements and observed results of the U.S. Department of Energy Superior Energy Performance program (Therkelsen et al., 2015).
- Annual interest rate of 1.83% used to calculate net present value, based upon 10 year US treasury note.
- Delivered energy consumption in 2025 and 2030 for the industrial and service sectors is projected to be 215 EJ and 229 EJ respectively (IEA, 2015b).

Figure 4 graphically illustrates the resulting uptake rates of ISO 50001 for the global industrial and service sectors based upon these assumptions.

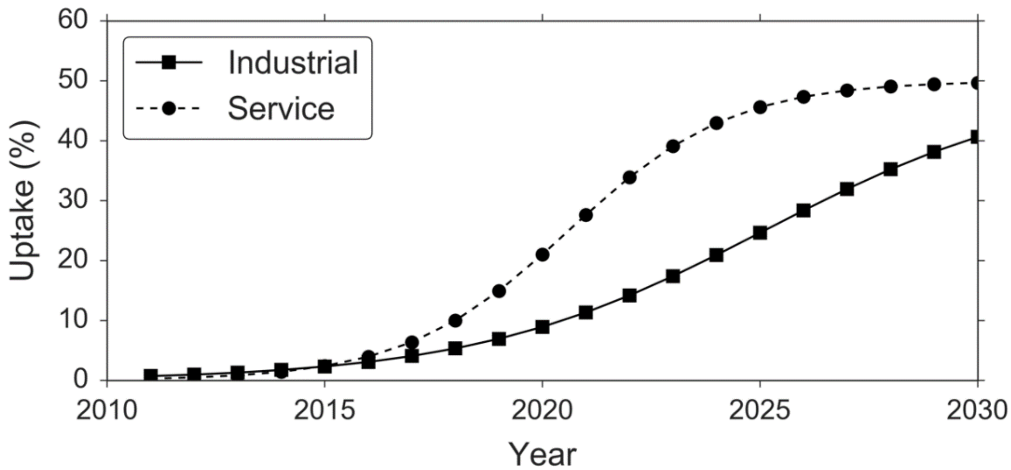

Figure 4: Uptake of ISO 50001 in the Global Industrial and Service Sectors based upon presented assumptions.

Under this scenario, in 2030 ISO 50001 implementation will result in approximately 16 EJ of primary *annual* energy savings, which translates to a 6% decrease in projected global industrial and service sector energy consumption. Additionally, 1000 million metric tons (Mt) of CO_2 will be avoided in 2030, equivalent to removing 210 million passenger vehicles from the road (EPA, 2014). The CO_2 emissions reductions contribute approximately 4% of the GHG reductions needed in 2030 to limit warming to 2° C by 2050 (UNEP, 2015). Annual primary energy and CO_2 emissions savings values for the global industrial and service sectors resulting from this analysis are presented in Figure 5.

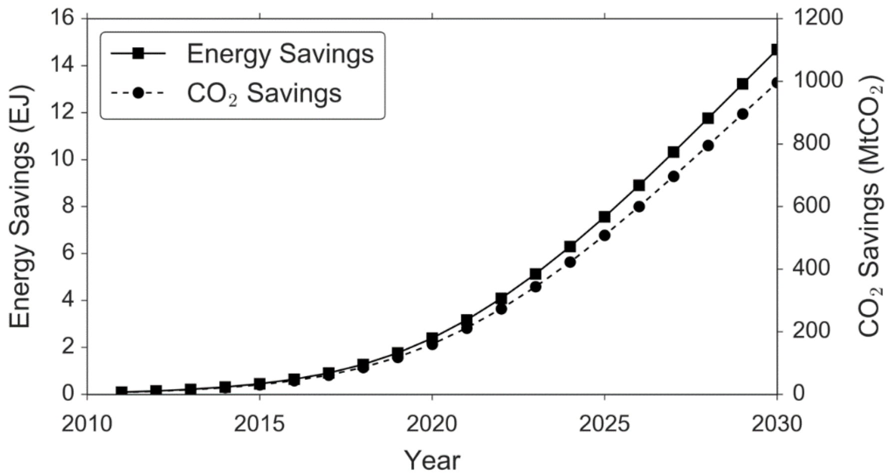

Figure 5: Annual Primary Energy and CO_2 Emissions Savings Resulting from Uptake of ISO 50001 in the Global Industrial and Service Sectors.

From 2011 to 2030, this scenario results in *cumulative* primary energy savings of approximately 105 EJ, cost savings of nearly US $700 billion (discounted to 2016 net present value), and an associated 6500 Mt of avoided CO_2 emissions.

7 Conclusion and Policy Implications

As governments work toward meeting emissions reductions goals, reducing energy from the industrial and commercial sectors will need to be addressed, and policies to increase the adoption of EnMS will play a key role. The implementation of the ISO 50001 continual improvement framework results in operational changes and deeper energy performance improvement actions, leading to energy reductions and avoided GHG emissions. While the culture change needed for ISO 50001 to succeed ultimately depends on individual organizations, enabling public policies can make implementation more effective and help ensure that energy savings are achieved and sustained over time.

The ISO 50001 Impacts Methodology and IET 50001 software were developed under the auspices of the EMWG as one component of its efforts to support robust ISO 50001 implementation worldwide. As an international forum, the EMWG conducts a number of activities that support national policies designed to increase EnMS and ISO 50001 adoption. These include: informational programs (fact sheets, case studies); recognition programs (Energy Management Leadership Awards); and activities to support EnMS robust implementation (through liaison to ISO Technical Committee 301, by developing an international ISO 50001 Lead Auditor Certification Scheme in support of consistent certification outcomes, and through a campaign to encourage uptake of ISO 50001). The EMWG has also undertaken an initiative to develop an international database of certified organizations to assist national governments in tracking the impact of their policies.

The ISO 50001 Impacts Methodology uses projections of energy consumption for a given country or region and models the percentage of energy coming under ISO 50001 management over time. This
methodology provides a flexible and transparent process to help policymakers understand the potential impact of ISO 50001 through both annual and cumulative energy savings estimates. With harmonized savings estimates across countries, policymakers can more easily compare impacts and learn from different policies. The methodology can facilitate and strengthen energy efficiency and energy management programs by allowing policymakers to understand the economic and environmental value of ISO 50001 implementation, design programs based on country- or region-specific analysis, and track program performance. Many national programs have already led to significant increases in ISO 50001 implementation, as shown in a number of examples in Appendix A. The ISO 50001 Impacts Methodology will allow program managers to estimate the impacts of this increased uptake, as well as model impacts from different uptake scenarios.

Program designers may wish to use the methodology to help set specific national or regional objectives and clarify and monitor how their program fits into broader energy and climate change mitigation goals. They can also use results from the methodology to guide how their program offerings, including financial incentives, technical assistance, workshops, or other activities, should be targeted within the industrial and commercial sectors. The methodology provides valuable information to aide policymakers in targeting public resources to maximize ISO 50001 impacts while accommodating the variation in energy uses and business practices of different subsectors. Because ISO 50001 provides a framework for continual improvement across an organization, programs in support of its implementation will also identify ongoing energy efficient opportunities, thus increasing the potential for increased uptake of energy efficiency at the project level. The widespread implementation of ISO 50001 will also create a more informed energy end-user market facilitating and accelerating the adoption of emerging energy efficiency technologies.

Assuming a 50% uptake level of ISO 50001 in the industrial and commercial sectors by 2030 along with other documented assumptions, IET 50001 projects that in 2030 ISO 50001 will result in approximately 16 EJ of *annual primary* energy savings, and 1000 Mt of avoided annual CO_2 emissions . This scenario results in *cumulative primary* energy savings between 2011 and 2030 of approximately 105 EJ, delivered cost savings of nearly US $700 billion (discounted to 2016 net present value), and an associated 6500 Mt of avoided CO_2 emissions. Actual uptake will depend on a number of factors and will increase as more enabling policies are established. As countries work towards meeting climate change mitigation goals, policymakers and other stakeholders can utilize the ISO 50001 Impacts Methodology and associated IET 50001 software to estimate country- and regional-level impacts of ISO 50001.

The development, review, and refinement of the methodology and IET 50001 tool has already engaged a global network of policymakers, academics, and technical experts – a necessary first step toward international adoption of ISO 50001 as a key climate change mitigation strategy. The ongoing engagement of the Impacts Network and other key policymakers will continue to strengthen the methodology and IET 50001 software tool, provide ongoing opportunities to share and track estimates of potential national and regional impacts from ISO 50001 implementation, and provide a forum for discussion and sharing EnMS program and policy best practices to support the realization of the ISO 50001 savings potential. Future work on the ISO 50001 Impacts Methodology and IET 50001 tool will include a sensitivity analysis of key inputs as well as establishing confidence intervals for results.

Appendix A

The descriptions presented here represent only a sampling of national program offerings currently supporting implementation of ISO 50001. As work within the Impacts Network progresses, it is anticipated that both the number and scope of national program offerings shared within the Network will increase.

Austria
The European Union Guideline 2012/27/EU, implemented through the Energy Efficiency Law (EEffG) in August 2014, requires any enterprise not classified as a small- or medium-sized enterprise (SME) to perform an Energy Audit at least every four years or to implement an Energy Management System (ISO 50001) or an Environmental Management System (ISO 14001 or EMAS) that includes the aspects of an energy audit. Although publicly available data are limited, there has been a significant increase in the number of EnMS implementations reported. During the first year of the EEffG requirement, covered enterprises reported identifying 11.15 PJ in energy savings.

Brazil
Brazil has been building a national policy framework in support of energy efficiency since the 2001 passage of the Energy Efficiency Law. The most recent revision to the National Plan for Energy Efficiency (PNef) recommends the implementation of ISO 50001 in the industrial sector. The revised PNef is expected to include a program to promote ISO 50001 uptake in Brazilian industry. In the absence of a supportive national policy, 23 facilities had already been certified to ISO 50001 as of 2014 (ISO, 2015).

Canada
In 2011, Canada implemented a voluntary program to increase the energy efficiency of all Canadian industry, regardless of size. The Energy Efficiency Program for Industry operates in conjunction with the Canadian Industry Program for Energy Conservation (CIPEC), a government-industry partnership that has been helping organizations improve energy efficiency since 1975. It offers networking opportunities through conferences and meetings, provides customized energy management workshops, and produces technical guides, case studies, videos, and newsletters to increase awareness and uptake of industrial energy efficiency. In addition, the Program provides CIPEC members with financial assistance to perform ISO 50001 implementation pilots, energy management projects, process integration studies, and/or computational fluid dynamics studies. To date, 17 facilities have been certified to ISO 50001, and two organizations are also certified to the United States Department of Energy's Superior Energy Performance program, with one organization implementing an Enterprise solution covering four of its facilities. In 2013 – 2014 alone, CIPEC organizations recorded total annual energy savings of 1.65 PJ–enough to power about 19,200 households – and reduced annual GHG emissions by an estimated 170 kt.

China
The Top 10,000 Enterprises Energy Efficiency and Low Carbon Action Plan requires approximately 17,000 industry and commercial enterprises accounting for 60% of China's energy consumption to establish an EnMS and obtain GB/T 23331-2012 or ISO 50001:2011 certifications.[3] All enterprises with an energy consumption of more than 5000 tons of coal equivalent were required to establish EnMS, including industry, transports, and commercial. In addition to the standard, enterprises also have access to both general and sector-specific EnMS implementation guidance. Additionally, implementation of an EnMS is now part of the evaluation of energy consumption for new and existing governmental investment programs.

Uptake of the standard has been higher in the more developed regions of the country, but remains slower than planned. By the end of 2015, there were 1847 enterprises certified to GB/T23331-2012 in China. Barriers to accelerated uptake include: lack of governmental incentives; a shortage of experts, especially trainers; and gaps in the internal capacity of some enterprises. Promotion of energy management will be a key strategy for achieving industrial emissions reductions and energy savings in the 13th 5-year plan and will include incentive schemes as well as mandates targeting the 10,000 largest energy consuming firms in industry.

Germany
In 2014, German companies held 3,402 ISO 50001 certifications, approximately 50% of the worldwide total. These results can be attributed to supportive national energy policies, including energy price and tax reductions, as well as technical assistance for the introduction of energy management systems.

The German Eco tax cap for industry was introduced in 1999 and began in 2013 to require companies falling under this scheme to operate an energy, environmental, or similar management system by the end of 2015. If the manufacturing industry as a whole improves its energy intensity by a certain percentage (1.35% in 2016), companies that comply can claim a reduction of electricity and/or energy taxes of up to 90%.
Another mechanism, the special equalization scheme, allows energy-intensive companies to request a partial exemption from the German renewable energy surcharge on electricity of 0.0624 EUR/kWh if they operate a certified environmental management system or EnMS (ISO 50001 or DIN EN 16001). A total of 1,069 certificates for energy management systems were submitted by companies in 2014 as a legal requirement in response to this scheme (BMWi, 2014).

In 2013, the Federal Office for Economic Affairs and Export Control (BAFA) fund began supporting the introduction of EnMS mainly in small- and medium-sized enterprises that are not eligible for the other schemes. BAFA allows for a total funding of up to EUR 20,000 per company within a period of 3 years, with specific allowances based on a percentage of costs incurred for initial certification of an EnMS, purchase of metering technology and/or energy management system software, energy consultant services, and training staff members as energy managers.

[3] GB/T 2331-2012 is aligned with ISO 50001, but is not included in the ISO Annual Survey

Ireland
Ireland has been actively engaged in promoting continual improvement of the energy performance of its industrial enterprises since publication of the Irish national energy management standard in 2005. Representatives from Ireland were active in the development of ISO 50001 Energy management system standard, which was adopted as a national standard following its publication in 2011. The Sustainable Energy Authority of Ireland (SEAI) continues to support uptake of ISO 50001 through its Large Industry Energy Network (LIEN), Energy Agreements programme and Public Sector Partnership programmes. There are 65 companies currently maintaining ISO 50001 certification. Recent publications for these programmes are listed under Sustainable Energy Authority of Ireland in the references section of this paper.

Ireland is currently developing additional energy management standards and programmes aimed to innovate and to drive deeper levels of energy performance, including a strong focus on continual improvement for mature EnMS as well as energy efficient design, construction, and commissioning.

Macedonia
Starting in May 2015, the United Nations Industrial Development Organization (UNIDO), in collaboration with the Macedonian Ministry of Environment and Physical Planning (MoEPP), the Ministry of Economy (MoE), the Energy Agency (EA), and the Macedonian Bank for Development Promotion (MBDP), began implementing a project targeted to overcome technical, financial, and policy barriers to improving energy efficiency in Macedonian industry. During the first project year, 10 companies representing approximately 10% of total national energy consumption were selected to implement an ISO 50001-aligned EnMS. Their energy management teams are receiving assistance from 20 national consultants who in turn are receiving extensive training in energy efficiency and energy management during the course of the project. The project is expected to have both direct and indirect impacts on Macedonian industrial energy consumption and to generate 67-76 kt CO_2eq cumulative direct and 66-72 kt CO_2eq of indirect GHG emissions reductions (GEF-UNIDO-REC, 2015).

Mexico
In 2014, the Commission for the Efficient Energy Use (CONUEE) launched the National Program of Energy Management Systems (PRONASGEn), which seeks to overcome and/or minimize the main barriers and bad practices that prevent energy users from the systematic adoption of energy efficient measures, while supporting the formal adoption of Energy Management Systems (EnMS). As a parallel effort, PRONASGEn is developing training to create national and international experts in EnMS and energy efficiency.

PRONASGEn operates primarily through “learning networks”. These networks integrate consulting firms, education and research institutions, and other diverse participants to assist in both the implementation of EnMS and the development of trainers. PRONASGEn is working with Germany, Denmark, the United States, and Canada, which contribute to six learning networks with more than 50 participants. There are three networks in the industry sector, two in the SME sector, and one in the federal sector. One of these networks extends through the three countries in North America. The PRONASGEn has also begun to export its knowledge and experiences to other countries in Latin America, beginning in May 2016 with two additional learning networks involving El Salvador, Nicaragua, Costa Rica and Germany. The detected barriers and needs will be used to create and improve the national policy in order to facilitate EnMS adoption for every sector in Mexico.

South Africa

Eskom, the largest electricity utility on the African continent, launched an Energy Efficiency and Demand Side Management program (EEDSM) in early 2002. Starting in 2004, the program was supported by the National Electricity Regulator (NER) through the approval of a levy on the electricity tariff. The program remains in existence and is hugely successful.

The Industrial Energy Efficiency (IEE) Project was established in 2010 in response to the growing need to improve the energy efficiency of South Africa. UNIDO, along with the Swiss Secretariat for Economic Affairs, the UK Department of International Development and partnered by the Department of Trade and Industry (the dti) and the Department of Energy (DoE) of South Africa, embarked on a program to address the global drive for greater energy efficiency. Since 2010 this project has introduced training courses to industry for a wide range of levels including energy experts, consultants, plant personnel, and practitioners. Project implementations were performed to demonstrate the impact of energy-efficiency practices on local industries. In the past four years (ending 2015), the IEE Project in South Africa has assisted industry in achieving energy savings worth over ZAR 1.541 Billion. The IEE Project assisted companies in developing and implementing an energy management system in line with the ISO 50001 Energy Management Standard, and supported companies' efforts to achieve this certification. 21 individuals were qualified as lead auditors for ISO 50001 certification purposes under the IEE Project. The IEE Project in South Africa was the first of its kind, developed from concept to implementation over five years – and has served as an international pilot project. Similar projects are now operational through UNIDO in 16 other developing countries worldwide.

The South African government also approved a tax incentive to the value of ZAR 0.45 per kWh (or kWh equivalent for any energy source), for achieved and verified energy efficiency saving from November 1, 2013, to any business. This incentive has since been increased to ZAR 0.95 per kWh (or kWh equivalent) from April 1, 2015 to encourage more businesses to implement energy efficiency projects.

The South African Department of Energy has introduced a measure that would make the preparation and submission of energy management plans mandatory for all enterprises with annual energy consumption in excess of 180 TJ. The policy measures previously introduced would complement this new requirement by using a combination of awareness-raising, assistance, and incentives to encourage firms to seek ISO 50001 certification. Consideration is also being given to reducing the threshold energy consumption above which energy management plans are mandatory. Incentives for smaller firms to achieve ISO 50001 certification might include rebates against carbon tax liability to cover part of the cost of obtaining and maintaining certification.

The development of learning hubs is being considered to help raise awareness of the possible benefits of ISO 50001 certification and provide resources that may be useful in the certification process.

Sweden

Sweden's "Program for Improving Energy Efficiency in Energy Intensive Industries" (PFE) operated as a voluntary program from 2005 until 2013 to increase energy efficiency in energy-intensive industries. Companies were required to become certified to an energy management standard (initially the Swedish national standard, later ISO 50001) within the first two years and implement identified energy efficiency measures over the following three years. Participation in the program exempted companies from the national tax on electricity and provided access to resources on energy management and implementation, networking, and workshops. The program resulted in a 10% savings in national electricity consumption, or approximately 3 TWh. Nearly all of the companies that participated in PFE have remained certified to ISO 50001. There has been an uptake of ISO 50001 at the enterprise level in the energy intensive industries as well as an increased interest in expansion into supplier networks.

Turkey

Turkey's 2007 Energy Efficiency Law, together with secondary legislation (2008) and additional amendments (2011), provides the basis for other energy efficiency policies. According to the legislation, industrial companies may be eligible for financial assistance if they adopt ISO 50001 and become certified. Eligible companies may receive financial assistance for as much as 30% of their energy efficiency investment. Companies that do not have ISO 50001 certification or are not in the process of applying are not eligible for the governmental support.

Most certifications are issued by TSE (Turkish Standard Institution), although some other private certification bodies also operate in Turkey. It is predicted that the number of certified industrial plants is around 160. For municipalities, there is only one big municipality who has recently been certified. One of the challenges is that there is no clear information on how many companies are certified because certification bodies do not release this statistical information.

There is currently no mechanism for auditing certification bodies in Turkey. TURKAK, the national accreditation body, is not yet accredited to ISO 50001. The lack of auditing means that certification bodies may be issuing certificates without evidence that all ISO 50001 requirements have been met.

United States

The United States Department of Energy established the voluntary Superior Energy Performance (SEP) Program in 2012 to build on ISO 50001 with specific energy performance improvement criteria. It requires adoption of ISO 50001 and includes third-party verification of energy performance improvements, which can help strengthen the business case for energy management to management and investors. Companies that meet the program requirements receive SEP certification at the Silver, Gold, or Platinum levels. The program offers technical assistance, training, software tools, and public recognition.

Companies earning SEP certification have achieved verified energy performance improvements of up to 30%, with a 12% average annual reduction in energy costs during the first 15 months of implementation and annual savings of up to US $938,000 using low- or no-cost operational measures. SEP is currently expanding its program to move beyond facility-level certification and cover Enterprise-wide implementation, which will help companies capitalize on economies of scale associated with adopting ISO 50001 (DOE, 2016).

References

Ahmed, A., Ploennigs, J., Menzel, K., Cahill, B., 2010. Multi-dimensional building performance data management for continuous commissioning. Adv. Eng. Informatics 24, 466–475. doi:10.1016/j.aei.2010.06.007

Backlund, S., Thollander, P., Palm, J., Ottosson, M., 2012. Extending the energy efficiency gap. Energy Policy 51, 392–396. doi:10.1016/j.enpol.2012.08.042

BMWi, 2014. Third National Energy Efficiency Action Plan (NEEAP) 2014 for the Federal Republic of Germany. Fed. Minist. Econ. Aff. Energy.

DOE, 2015. Barriers to Industrial Energy Efficiency, United States Department of Energy. doi:10.1108/IJESM-05-2013-0008

Duarte, C., Acker, B., 2011. Prioritizing and visualizing energy management and control system data to Provide Actionable Information for Building Operators, in: Western Energy Policy Research Conference.

EIA, 2013. International Energy Outlook 2013, United States Energy Information Administration.

EMWG, 2016a. Overview [WWW Document]. Energy Manag. Work. Group, Clean Energy Minist. URL http://www.cleanenergyministerial.org/Our-Work/Initiatives/Energy-Management/EMWG-Overview (accessed 5.12.16).

EMWG, 2016b. ISO 50001 Impact Estimator Tool [WWW Document]. URL http://www.cleanenergyministerial.org/Our-Work/Initiatives/Energy-Management/iet50001 (accessed 5.15.16).

EMWG, 2014. Models for Driving Energy Efficiency Nationally Using Energy Management, Energy Management Working Group, Clean Energy Ministerial.

EPA, 2014. Greenhouse Gas Equivalencies Calculator [WWW Document]. Environ. Prot. Agency. URL https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator (accessed 5.6.16).

Fischedick, M., Roy, J., Abdel-Aziz, A., Acquaye, A., Allwood, J.M., Ceron, J.-P., Geng, Y., Kheshgi, H., Lanza, A., Perczyk, D., Price, L., Santalla, E., Sheinbaum, C., Tanaka, K., 2014. Industry, Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

GEF-UNIDO-REC, 2015. Project document for “Catalyzing market transformation for industrial energy efficiency and accelerate investments in best available practices and technologies in the Former Yugoslav Republic of Macedonia.”

IEA, 2015a. Energy and Climate Change, World Energy Outlook Special Report. Paris, France. doi:10.1038/479267b

IEA, 2015b. Energy Technology Perspectives, International Energy Agency. Paris, France. doi:10.1787/energy_tech-2014-en

IIP, 2012. Energy Management Programmes for Industry, Institute for Industrial Productivity, International Energy Agency. Washington, DC.

ISO, 2015. The ISO Survey of Management System Standard Certifications - 2014 [WWW Document]. Int. Stand. Organ. URL http://www.iso.org/iso/iso-survey (accessed 12.5.16).

Lucon, O., Ürge-Vorsatz, D., Zain Ahmed, A., Akbari, H., Bertoldi, P., Cabeza, L.F., Eyre, N., Gadgil, A., Harvey, L.D.D., Jiang, Y., Liphoto, E., Mirasgedis, S., Murakami, S., Parikh, J., Pyke, C., Vilariño, M.V., 2014. Buildings, Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. doi:10.2753/JES1097-203X330403

McKane, A., Desai, D., Matteini, M., Meffert, W., Williams, R., Risser, R., 2009. Thinking Globally: How ISO 50001-Energy Management can make industrial energy efficiency standard practice. Lawrence Berkeley Natl. Lab.

Reinaud, J., Goldberg, A., 2014. The more the merrier : leveraging diverse players to deploy energy management systems in industry, in: ECEEE Industrial Summer Study Proceedings. pp. 689–697.

Schreck, B., 2011. What are the steps to adopt Energy Management Systems?

Sustainable Energy Authority of Ireland, 2016. http://www.seai.ie/LIEN-Report/; http://www.seai.ie/Your_Business/Large_Energy_Users/LIEN/LIEN_Reports/; http://www.seai.ie/Your_Business/Public_Sector/. (accessed 6.24.16)

Sorrell, S., Mallett, A., Nye, S., 2011. Barriers to industrial energy efficiency: a literature review, United Nations Industrial Development Organisation.

Tanaka, K., 2011. Review of policies and measures for energy efficiency in industry sector. Energy Policy 39, 6532–6550. doi:10.1016/j.enpol.2011.07.058

Therkelsen, P., McKane, A., Sabouni, R., Tamm, Y., Rao, P., Scheihing, P., 2015. Development of an Enhanced Payback Function for the Superior Energy Performance Program, in: ACEEE Summer Study on Energy Efficiency in Industry.

UNEP, 2015. The Emission Gap Report 2015. A UNEP Synthesis Report, United Nations Environment Programme.

UNIDO, 2011. Industrial Development Report 2011: Industrial energy efficiency for sustainable wealth creation, United Nations Industrial Development Organization. Vienna, Austria.

UNIDO, 2010. Motor Systems Efficiency Supply Curves, United Nations Industrial Development Organisation. Vienna, Austria.

UNIDO, 2008. Policies for Promoting Industrial Energy Efficiency in Developing Countries and Transition Economies, United Nations Industrial Development Organisation. Vienna, Austria. doi:http://industrial-energy.lbl.gov/node/29

Worrell, E., 2011. Barriers to energy efficiency: International case studies on successful barrier removal, United Nations Industrial Development Organization - Development policy, Statistics & Research branch.