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Development of a readiness for change maturity model: an energy management system implementation case study

Zineb Britel[1]*, Abdelghani Cherkaoui[1]

[1] Mohammadia School of Engineers EMI, Mohammed V University, Ibn sina Avenue B.P. 765 Agdal Rabat, Morocco; cherkawi@emi.ac.ma (AC)
*Correspondence: britelzineb@gmail.com

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Abstract
This paper provides a methodology to assess the maturity of an organization's readiness for change based on the use of a Fuzzy Analytic Network Process and fuzzy linguistic evaluation maturity model. This anticipatory approach's purpose is to evaluate the extent in which an organization is ready to implement a change initiative, in order to enhance supportive behaviors and identify improvement areas before engaging the change and thus reducing change adoption failure risks. A case study for the implementation of an Energy Management System according to the ISO 50001 Standard within a factory operating in the automotive sector is provided. Rather than the classical technical approach found in energy management maturity models, this approach offers an organizational perspective. The use of the Fuzzy Analytic Network Process allows the consideration of the interrelations between factors, while the use of fuzzy logic for the evaluation through linguistic variables helps in taking the uncertainty and imprecision of respondents into consideration. This approach serves as a decision support system for decision-makers by providing the organization's readiness maturity level as well as the identification of improvement areas that will help ensure a successful implementation of the desired change initiative. In the conducted case study, the obtained maturity level refers to an average readiness for change for the implementation of the Energy Management System and requires the definition of an improvement roadmap, comprising the following elements: ensuring top management leadership and organizational commitment and involving employees as well as internal communication on the personal and organizational benefits of the implementation of an Energy Management System.

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1. Introduction

In response to climate change and sustainability challenges, reducing their energy consumption has become crucial for countries to meet their national greenhouse gas (GHG) reduction commitments. Morocco has committed to reduce its GHG emissions by 17% below business-as-usual levels by 2030, with an additional 25% conditional on international support following the ratification of the Paris Agreement in September 2016 (UNFCCC, 2016; Terrapon-Pfaff and Amroune, 2018). In June 2021, Morocco enhanced its Nationally Determined Contribution to 45.5% by 2030 (with 27.2% of this target being conditional to international assistance) (Ministry of Energy, Mines and the Environment, 2021).

Since 2009, Morocco has deployed a national energy strategy that serves as a roadmap for the transition to a low-carbon energy system with a 2030 horizon. It revolves around five priorities: the optimization and diversification of the energy mix, the mobilization of domestic resources and particularly renewable energy use, the promotion of energy efficiency, building stronger regional cooperation with Europe's and Africa's energy markets, and industrial integration by developing local industrial capabilities. This strategy's implementation relied on energy sector reforms, increased transparency and competition, as well as capacity building…It aims at securing the country's energy supply and ensuring energy availability and affordability. Thus, contributing to the reduction of the country's energy dependence, the improvement of citizen's purchasing power, industries competitiveness and public accounts…

Morocco possesses valuable renewable energy resources that can help it meet its energy needs. It benefits from an average solar radiation of 5.3 kWh/m^2 annually and with sunshine durations of more than 3000 h/year (Ministry of Energy,

Mines, Water and the Environment, 2020). The country also benefits from a significant wind resource, with 3500 km of coastline and mean wind speeds varying between 7.5 m/s to 9.5 m/s in the south (Tarfaya, Taza, Laayoun, Dakhla) and up to 11 m/s in the North (Tangier, Tetouan) (Kousksou, et al., 2015; Ministry of Energy, Mines, Water and the Environment, 2020). Morocco's potential for renewable energies is illustrated by initiatives such as: the Moroccan Solar Plan and the Moroccan Integrated Wind Energy Program.

According to a comparative analysis on energy efficiency and renewable energy strategies and policies within Southern and Eastern Mediterranean countries (Lebanon, Jordan, Palestine, Egypt, Libya, Tunisia, Algeria, Morocco) by the (Mediterranean Association of the National Agencies for Energy Management; Regional Centre for Renewable Energy and Energy Efficiency, 2019), the countries with the most ambitious energy efficiency national targets by 2030 are Tunisia (30%) and Morocco (20%). Regarding renewable energy national targets, Morocco and Egypt have the most ambitious targets with Morocco's goal of 52% share of renewable energy in energy production by 2030 that was updated and enhanced in 2021 to aim for an installed power capacity of 52% by 2025 and 64.3% by 2030 (Hayoun, 2021), and the Egyptian strategy's goal of 42% share of renewable energy in energy production by 2035.

According to the International Energy Agency (IEA), the industrial sector was responsible for 20.9% of final energy consumption in Morocco in 2018 (International Energy Agency , 2018). Therefore, a wide dissemination of the energy management standard ISO 50001 within industrial organizations, presents a good opportunity. This standardized continuous improvement framework helps to foster energy efficiency and reduces the emission of greenhouse gases. It also helps organizations ensure legislative compliance, gain a competitive advantage, provide a cost reduction opportunity in relation to energy consumption and improve operational efficiency as well as demonstrating some aspects of their corporate social responsibility.

Ensuring the readiness for change of an organization prior to engaging the implementation of a change initiative is often regarded as critical to the success of the change (By, 2007; Rafferty, et al., 2013; Weiner, et al., 2020), and helps enhance change supportive behaviors (Rafferty, et al., 2013), employee's cooperativeness, sense of initiative and persistence (Weiner, 2009). Therefore, developing a readiness for change maturity model that evaluates the extent in which an organization is ready to implement a change initiative can be highly beneficial for companies and can play an important role in reducing failure risks related to the adoption of a change initiative or a new project. In this paper, we will explore the readiness for change aspects in the case of the implementation of an Energy Management System (EnMS) within a Moroccan factory.

This paper's contribution to the literature can be summarized as follows:

- Proposing a change readiness evaluation framework based on readiness for change literature review.
- Contrary to the classical technical approaches found in energy management maturity models, the proposed approach explores the organizational dimension linked to the adoption of an Energy Management System.
- Relying on an anticipatory approach, the proposed readiness evaluation framework gives an alternative to the bias present in retrospective employee reports (Cunningham, et al., 2002; Rafferty, et al., 2013) and meets the need for more acute measurement methods as described by (Holt and vardaman, 2013).
- The proposed evaluation framework takes the human factor's inherent uncertainty and imprecision into consideration (using fuzzy logic and fuzzy linguistic variables). This is particularly useful since the human factor is at the core of technology acceptance research and change management.
- Using the Fuzzy Analytic Network Process makes it possible to consider the interdependencies between the studied concepts.
- Several managerial implications in practice such as the identification of the company's readiness for change maturity level regarding the implementation of an Energy Management System and helping in the construction of a targeted improvement roadmap based on the evaluation's results. This approach has also the potential to be generalized for similar studies.

The goals of this study are to provide corporate decision-makers who want to evaluate the current level of readiness for the implementation of an Energy Management System for their organizations with a suitable model that adheres to the particularities of each organization. As well as providing a decision-aid tool for the identification of areas that further need to be addressed prior to engage with the change initiative.

The structure of this paper is organized as follows; section two presents a literature review on energy management maturity models, the concept of change readiness and its related factors, followed by the description of the proposed methodology for the change readiness evaluation of the EnMS implementation in section three. Section four presents the obtained results and findings for a manufacturing plant based in Morocco and operating in the automotive sector that are further discussed in section five. Finally, the last section presents the conclusion of the study.

2. Literature review

The conducted literature review considered both the implementation of an Energy Management System and the concept of change readiness.

2.1. Energy Management System implementation

A common approach in the literature of Energy Management System implementation is to define an energy management maturity model that measures the maturity to implement energy management actions. A maturity model in general, allows to represent the progress and evolution in a specific do-

main across levels through measurable transitions. It is composed by levels that represent the transitional states of the model, model domains that represent the knowledge areas of the model and that are in turn composed by attributes, Appraisal and Scoring Methods to conduct the assessment. They can be used for benchmarking purposes or to define improvement roadmaps (Caralli, et al., 2012). Maturity in the studied context refers to the organization's capabilities to manage energy ranging from procurement to utilization. Energy management maturity models help structure energy management practices and orient investments (Antunes, et al., 2014) and can serve as a strategy to scale up energy efficiency actions' impacts (O'Sullivan, 2011).

In the recent years, few studies addressed energy maturity models (Finnerty, et al., 2017). Among the existing energy management maturity models, there is: the energy and utility management maturity model for sustainable manufacturing process (Ngai, et al., 2013), the energy management maturity model by (Introna, et al., 2014), the ISO 50001 standard-based energy management maturity model (Jovanović and Filipović, 2016), the energy management maturity model by (Antunes, et al., 2014), the energy management maturity model for multi-site industrial organizations with a global presence (Finnerty, et al., 2017).

The common factor between these models is that they have five levels of maturity and most of them align with the Plan Do Check Act cycle (Antunes, et al., 2014; Finnerty, et al., 2017; Introna, et al., 2014; Jovanović and Filipović, 2016). The models proposed by (Introna, et al., 2014) and (Jovanović and Filipović, 2016) are closely linked to the ISO 50001 Standard and can be considered complementary to the standard. Ngai et al's model (2013) does not permit the definition of an organization's maturity, however the progress description between levels provides guidance for companies in their improvement journey. The particularity of the energy management maturity model by (Finnerty, et al., 2017) is that it focuses on global multisite organizations. However, implementation activities for a successful adoption of an EnMS are subject to limited scientific literature (Antunes, et al., 2014), and existing maturity models focus on the organization's maturity in energy management, but not in an organizational readiness perspective that is based on an anticipatory approach prior to the adoption of the EnMS, as proposed by this study.

2.2. The concept of readiness for change

The concept of change readiness is a multilevel construct (individual, group, organization…), that has been given many definitions across the literature. (Armenakis, et al., 1993) defines the concept from the individual's perspective as its "beliefs, attitudes, and intentions regarding the extent to which changes are needed and the organization's capacity to successfully undertake those changes". while the definition provided by (Holt, et al., 2010) refers to the extent to which the people involved are "individually and collectively primed, motivated, and technically capable of executing the change". In this paper, the influence of the social sphere (Dievernich, 2015) is taken into consideration by considering both the individual's and the organization's levels of analysis, especially since only few readiness evaluation tools (7%) allow the measurement of both the individual and organizational levels of readiness (Holt and vardaman, 2013; Weiner, et al., 2020). A capability's perspective is also taken into consideration, it is inspired by the structural approach (weiner, et al., 2008) that is based on capabilities and resources.

The concept of change readiness has been the subject of several literature reviews that explored some existing evaluation tools for organizational change readiness (Gagnon, et al., 2014; weiner, et al., 2008; Weiner, et al., 2020). These evaluation tools can be associated to different goals such as: readiness description purposes, studies of change related attitudes, adoption and implementation prediction, prediction of other outcomes like employee turnover and job satisfaction. This study's aim falls within the three first categories, it helps to answer the questions: How ready is the company for the change? And what factors should be addressed to improve change related attitudes and capabilities?

According to a recent review on change readiness (Weiner, et al., 2020), the most used readiness tools are the "Texas Christian University Organizational Readiness for Change (TCU-ORC)" (Lehman and Simpson, 2002), the "Individual Readiness for Organizational Change (IROC)" (Holt, et al., 2007), the "Organizational Readiness to Change Assessment (ORCA)" (Helfrich, et al., 2009). The ORCA (19 scales and 77 items) and the TCU-ORC (18 scales and 118 items) are considered quite long. Other existing instruments with promising psychometric properties according to (Weiner, et al., 2020) are the organizational readiness for implementing change (Shea, et al., 2014), the perceived organizational readiness for change (Cinite, et al., 2009), the organizational change recipients beliefs scale (Armenakis, et al., 2007), the Organizational Change Questionnaire–Climate of Change, Processes, and Readiness (OCQ–C, P, R) by (Bouckenooghe, et al., 2009). In contrast with the existing survey-based evaluation tools the originality of the proposed evaluation framework, lies in the consideration of uncertainty and imprecision inherent to the human factor, combined with a maturity evaluation that is practical for decision-making in a managerial context.

Other change readiness studies focused on the change message, and the factors that lead to readiness through it (Armenakis and Harris, 2002; Berneth, 2004). Therefore, a full category was dedicated to it in the proposed framework.

Exploring the different dimensions of the concept of change readiness, the conducted literature review helped structure the perspectives to be included in the proposed evaluation model (both individual and organizational perspectives, capabilities perspective, communication and change readiness messages).

In the following section, we will also present the change readiness factors that also emerged from reviewing the literature on change readiness evaluation tools and factors. The justification of each factor or association is provided in Table 1. These change readiness factors, validated in previous studies, are the ones that will form the proposed evaluation framework.

Table 1. The proposed framework justifications

Category description	Sub factors description	Justification
Change context: The organizational context of the planned change	• Organizational politics: The perceived level of political games within the organization (Weiner, 2009) • Past-experience: Positive or negative experience with change (Weiner, 2009) • Policies and procedures: Existing company policies and procedures (Weiner, 2009) • Environment and organizational climate: The organizational culture of the company (Weiner, 2009) • Cohesion: The perception of togetherness, cooperation and sharing (Bouckenooghe, et al., 2009) • Discrepancy: A sense of urgency or the need for change, it is the realization that there are legitimate reasons for the change (Holt, et al., 2007)	We maintained the placements of organizational politics, policies and procedures, organizational culture and past-experience within contextual factors (Weiner, 2009). Cohesion is placed in the context factors (Bouckenooghe, et al., 2009), and discrepancy is placed within the internal change context category (Holt, et al., 2007).
Change content: The content of the planned change	• Organizational valence: The realization of the change's benefits on the organization. • Appropriateness of the change: The planned change is well suited for the organization.	The two factors are supported by Holt, Armenakis, Field et al (Holt, et al., 2007)
Structural factors: The availability of necessary structure, resources and workers knowledge, skills, and their abilities alignment with the change.	• Knowledge, skills, ability alignment (Holt and vardaman, 2013) also present in people category (Combe, 2014) • Organizational resources and structure (weiner, et al., 2008) that is extended to other elements such as Processes, Technology/ support resources, physical resources and organizational systems (Combe, 2014).	Holt and vardaman place knowledge, skills and ability alignment within the structural factors (Holt and vardaman, 2013). We include the organizational resources and structure inspired by the capacity assessment.
Change process readiness: The process of the implementation of the change **(Bouckenooghe, et al., 2009)**	• Management support: The support and understanding of immediate supervisors towards employees (Bouckenooghe, et al., 2009; Holt, et al., 2007) • Attitudes of Top management: The position of top management towards the change (Bouckenooghe, et al., 2009) • Participation: The involvement of employees with the change and keeping them informed of decisions that interest them (Bouckenooghe, et al., 2009).	Quality of change communication is placed in the process category (Bouckenooghe, et al., 2009), however we placed this factor in a dedicated change communication readiness category.
Change communication readiness	Communication on: • Discrepancy: Communication about the necessity to change • Efficacy: Communication on the confidence in employee's ability to implement the change • Appropriateness of the change: Communication on change's accuracy regarding the discrepancy identified. • Principal support: Communication on the support of leaders. • Valence: Communication on change benefits. • Quality of change communication: The way the change is communicated and its effectiveness (clarity, frequency and openness) (Bouckenooghe, et al., 2009)	(Armenakis and Harris, 2002; Berneth, 2004) support the first five message components.
Change agent attributes: The change agents are the individuals that lead the change within the organization	• Perceived credibility: The credibility of a message source with no regard to the content. • Trust worthiness: The ability to be relied on as honest or truthful (oxford dictionary) • Sincerity: The absence of pretense, deceit or hypocrisy (oxford dictionary) • Expertise: Both content expertise about the change and change process expertise (Baker, 1995).	The factors are supported by Turner (Turner, 1982). Armenakis and Fredenberger insist on employee's confidence in change agent's expertise (Armenakis and Fredenberger, 1997).
Change recipient's individual factors	• Values: Principles or standards of behavior (oxford dictionary) • Self-efficacy: Individual's confidence in its own ability to perform the change. • Yield-Personal valence: The benefits or rewards that may result from the change.	(Baker, 1995) supports values. Self-efficacy and yield are considered important individual change readiness attributes (Holt, et al., 2007).

Change recipient's organizational factors	• Vision for change: The construction of a vision of what is the change, why, how to achieve it (Kotter, 1995; Smith, 2005) • Organizational commitment: The dedication and belief in the organization's goals and values (Identification, involvement and loyalty) (Holt and Vardaman, 2013; Weiner, 2009) • Trust in leadership: The perceived trustworthiness of employees towards their supervisors and top management (Bouckenooghe, et al., 2009; Holt and vardaman, 2013) • Collective efficacy: Group's confidence in its own ability to perform the change (Baker, 1995; Holt and Vardaman, 2013; Weiner, 2009). • Social relationships: Work relationships between employees: peers, supervisors, subordinates (feelings, attitudes, perceptions…).	(Bouckenooghe, et al., 2009) places trust in leadership within the context factors. We placed it within the collective attributes as suggested by (Holt and Vardaman, 2013) where it is named as collective trust. Also, (Madsen, et al., 2005)'s study shows a relationship between change readiness and social relationships.

Following the conducted literature review, a focus group was carried out. It was composed by three change management experts, with more than fifteen years of experience as change management consultants, that have collaborated with several firms on different transformation and organizational projects. The aim of the focus group was to validate the proposed factors and discuss the framework structure. As a result, all proposed factors and subcategories of factors emanating from the literature were maintained by the experts. However, for the quality of change communication factor, it was moved to the change readiness communication subcategory following the experts' suggestion. The subfactors categories were then regrouped by the experts in four interdependent categories: change characteristics, change capabilities, change implementation process and change recipients, as illustrated in Figure 1.

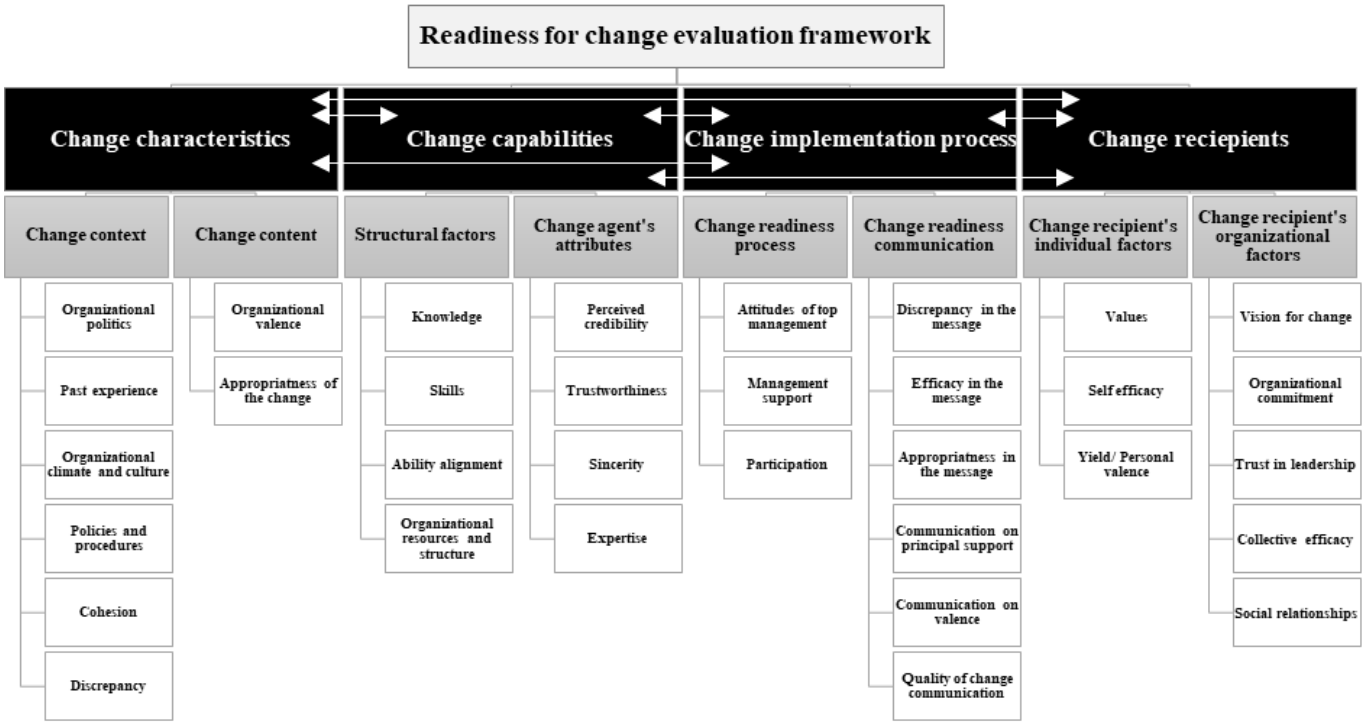


Fig. 1. Change readiness evaluation framework

3. Methodology

The proposed methodology for the assessment of the organization's readiness for change in the case of the implementation of an EnMS according to ISO 50001 standard is described in Figure 2. The detailed steps will be provided after describing the case study and the study design.

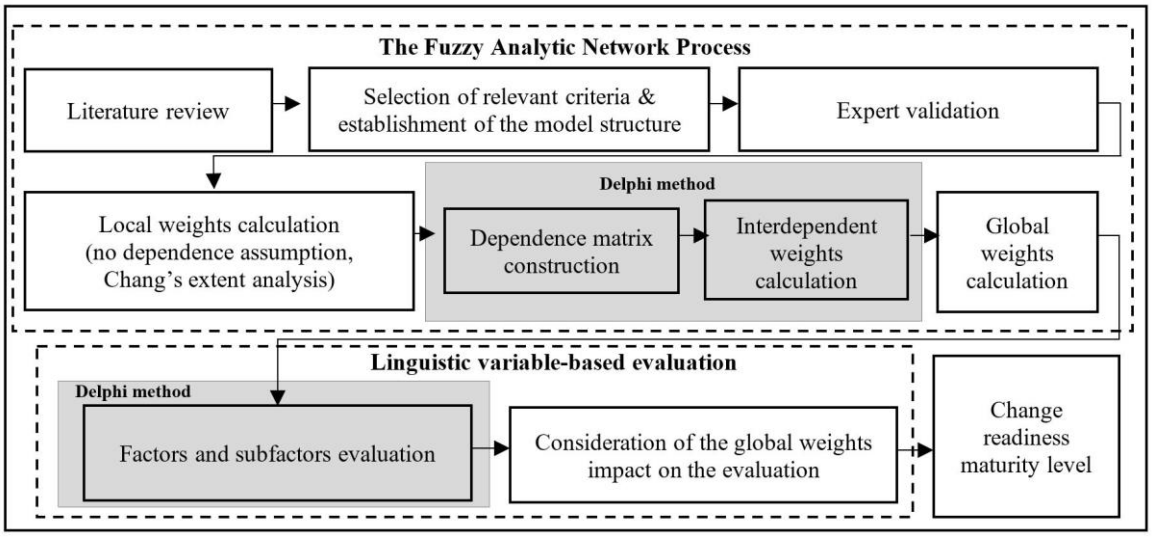


Fig. 2. Framework for the assessment of an organization's change readiness maturity level

3.1. Case study description

The automotive sector in Morocco has benefited from a strategic continuity through the emergence Plan followed by the Industrial Acceleration Plan, to reach an important place within the national industry. Morocco is considered the leading automobile producer on the African continent since 2017 and the 2nd exporter to Europe from the first half of 2021. There are currently 250 equipment manufacturers installed in Morocco (Ministry of Industry, Trade, Green and Digital Economy, 2021).

This case study takes place in a factory that specializes in the assembly of light commercial vehicles based in Morocco. The process of the assembly of the produced vehicles at the plant goes through five main stages: Sheet metal work, painting, assembly and finally finishing and delivery.

As part of the maintenance and reliability team's technical and operational watch activities and benchmarks, the project of the implementation of an EnMS according to the ISO 50001 standard (2018 version) was proposed to top management.

The objectives of the EnMS implementation project are the following:

- Improving the energetic performance of the factory through a better usage of energetic resources
- Achieving cost-effectiveness by reducing energy-related costs
- Developing efficiency energy practices within the company
- Adoption of a dynamic process towards continuous improvement and obtaining the ISO 50001 certification
- Contribution to sustainable development national efforts and exhibiting the company's corporate social responsibility.

Considering the company's previous experience with other management systems like quality management, occupational health and safety, environmental management. Top management required an appropriate change conduct to be realized to gain employee's support and adherence to ensure the success of the project. In this regard, it is important to know how ready is the company for the change? And what factors should be addressed to improve change related attitudes and capabilities of employees regarding the implementation of the EnMS?

3.2. Study design

To conduct the change readiness evaluation for the implementation of an energy management system within the Moroccan manufacturing company, the authors relied on a second focus group. It was composed by the focus group members in Table 2, that are considered experts in their respected fields within the company, all members have at least seven years of experience within the factory and have taken part in important transversal projects in the past.

Table 2. Focus group composition

Function	Number
Production engineers	2
Production planner	1
Purchasing team members	2
Maintenance and reliability engineers	2
Logistics team members	2
Quality management engineers	2
Communication team members	1
Engineering team members	2

The Focus group session started with an introduction on the ISO 50001 standard (2018 version) and the description of the EnMS implementation project objectives, as well as a brief overview of the proposed methodology, and particularly the use of the Delphi Technique.

The proposed methodology relies on the Fuzzy Analytic Network Process to attribute weights to the change readiness evaluation framework's factors and subfactors while consid-

ering the factor's dependencies. Then, a fuzzy linguistic variable based evaluation is carried out, it allows the definition of the organization's readiness maturity level and to propose a targeted improvement roadmap by focusing the factory's efforts on factors with low or medium evaluation results. The Delphi method is used throughout this process to reach a consensus between the focus group members. The detailed methodological steps are provided in sections 3.3, 3.4 and 3.5.

3.3. Fuzzy Analytic Network Process methodology

The Analytic Network Process (ANP) is a generalization of Saaty's Analytic Hierarchy Process (AHP) (Saaty, 1990). The AHP helps in making a decision across several alternatives and it also helps determine the relative importance of criteria. It relies on the construction of the evaluation index system as a hierarchy, followed by the elaboration of pairwise comparison matrices based on expert's judgements with consistency tests. The AHP relies on the assumption of functional independence of the hierarchy's upper part in regard to its lower parts, and each level criteria. The ANP however, is usually used to take the interdependence of the model's criteria into account. Fuzzy logic helps in dealing with complex problems and with the human's factor inherent uncertainty (imprecision, vagueness, subjectivity…). These are the reasons for the choice of the Fuzzy Analytic network process combined with a fuzzy linguistic variable based evaluation. The steps of the proposed methodology are described below:

Step 1: Identification of the goal, factors and sub-factors of the model hierarchically

After conducting a literature review on change readiness frameworks and factors and conducting a focus group with three change management experts, the evaluation framework in Figure 1 was developed. The definitions of the proposed factors, their supporting studies and the framework structure justifications are given in Table 1 within the literature review section.

Step 2: Determination of the factors and sub-factors local weights using pairwise comparison matrices, with the assumption of no dependence among the factors.

During the second focus group meeting within the company (the focus group composition is given in Table 2), the triangular fuzzy number-based scale, displayed in Table 3 was used, it is proposed by (Kahraman, et al., 2006) to construct the pairwise comparison matrices.

Table 3. Triangular fuzzy scale

Linguistic scale for importance	Triangular fuzzy scale
Just Equal	(1, 1, 1)
Equally Important	(1/2, 1, 3/2)
Weakly more important	(1, 3/2, 2)
Strongly more important	(3/2, 2, 5/2)
Very strongly more important	(2, 5/2, 3)
Absolutely more important	(5/2, 3, 7/2)

Let $X = \{o_1,o_2,..,o_n\}$ be an object set, and $U=\{g_1,g_2,..,g_m\}$ be a goal set.

For every object, and for every element of the goal's set g_i the analysis is conducted.

For each object, m extent analysis values are symbolized by $\tilde{M}_j g_i$ with (j=1,...,m) representing the triangular fuzzy numbers, with the membership function represented by $\tilde{M}(x)$.

Using Chang's extent analysis method (Chang, 1996) due to the simplicity of its steps in comparison with other similar approaches (Dağdeviren, et al., 2008; Britel and Cherkaoui, 2020). The fuzzy synthetic extent value is calculated in regards to the i^{th} object with the formula:

$$Si \approx \sum_{j=1}^{m} \tilde{M}_j g_i \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} \tilde{M}_j g_i\right]^{-1} \quad (1)$$

With the expression below, the degree of possibility of $\tilde{M}2$ (l_2,m_2,u_2) being greater than $\tilde{M}1$ (l_1,m_1,u_1) is calculated:

$$V(\tilde{M}_2 \geq \tilde{M}_1) = \sup[\min(\tilde{M}_1(x), \tilde{M}_2(y))] \quad (2)$$

$$= \begin{cases} 1, \ if\ m2 \geq m1 \\ 0, if\ l1 \geq u2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, otherwise \end{cases} \quad (3)$$

To compare $\tilde{M}_1$ and $\tilde{M}_2$, the requirement is to have $V(\tilde{M}_1 \geq \tilde{M}_2)$ and $V(\tilde{M}_2 \geq \tilde{M}_1)$. Then the degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers is calculated, with i=1,2,…,k :

$$V(\tilde{M} \geq \tilde{M}_1, \tilde{M}_2, \ldots, \tilde{M}_k) = \min V(\tilde{M} \geq \tilde{M}_i) \quad (4)$$

The weight vector is given by the following expression, for k= 1, …, n :

$$W = (\min V(S_1 \geq S_k), \min V(S_2 \geq S_k), \ldots, V(S_n \geq S_k))^T \quad (5)$$

Step 3: Determination of the dependence matrix for every factor with respect to the other ones. The dependence matrix is formed using pairwise comparisons between the factors along with Chang's extent analysis method, with a focus on the impact of each factor on the others.

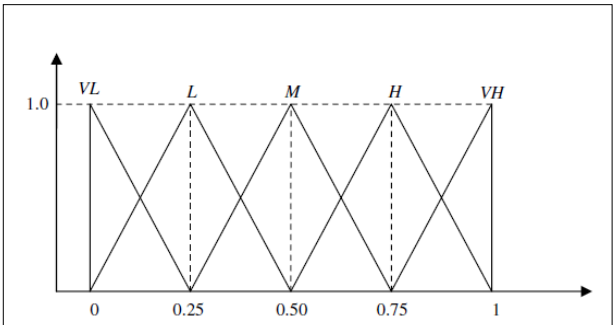
Step 4: Calculation of the interdependent weights of the factors by multiplying the inner dependence matrix with the factor's local weights.

Step 5: Calculation of the sub-factors global weights by multiplying the sub-factor's local weight with the interdependent weights of its corresponding factor.

3.4. Fuzzy evaluation

The fuzzy linguistic variable-based evaluation is carried out through the following steps.

Step 6: Evaluation of the factors and subfactors using linguistic variables. Using Cheng's linguistic variables (1999), with the membership functions and the average values of the variables given in Figure 3, the evaluation is carried out.



Linguistic values	Mean values of fuzzy numbers
Very high (VH)	1
High (H)	0.75
Medium (M)	0.5
Low (L)	0.25
Very low (VL)	0

Fig. 3. Membership functions for the linguistic values and their means of fuzzy numbers

Step 7: Evaluate the global readiness for change by multiplying the corresponding fuzzy number to the linguistic values and the global sub-factor weights

3.5 Maturity model perspective

From a managerial perspective, determining the maturity level of the organization regarding the planned project can be useful for decision-making and easily interpreted. It has two main advantages: the identification of the current maturity level and the identification of improvement areas, in an anticipatory approach before the implementation of the planned change. Thus, improving the chances of success of the project.

Step 8: Definition of the readiness for change maturity level. According to the scale proposed by Britel and Cherkaoui (2020) in Table 4, the readiness for change maturity level (RCML) is determined based on the maturity level (ML) obtained value.

Table 4 Readiness for change maturity levels

Maturity level values	Readiness for change maturity level (RCML)
ML ≤0.2	"No Readiness for change"
0.2< ML ≤0.4	"Low Readiness for change"
0.4<ML≤0.6	"Average Readiness for change"
0.6<ML≤0.8	"Good Readiness for change"
0.8<ML≤1	"Excellent Readiness for change"

It is important to note that for steps n° 2, 3 and 6, obtaining a consensus between the focus group members was necessary, therefore a two-round Delphi methodology was used. The Delphi methodology is well-known for structuring the communication process within a group of experts (in our case, the designated focus group members) with the aim of reaching a consensus concerning a complex problem. It allows the experts to receive feedback reports and gives them the opportunity to improve their opinions based on the received feedback (Dalkey and Helmer, 1963). Two rounds of questioning were used:

- In the first round, separate consultation interviews were organized with each member of the focus group.
- After this first round, the data collected was synthetized and analyzed (identification of extreme values, major differences...). The obtained results were then returned to the experts with the opportunity to whether justify and maintain their values or improve their propositions. This first round led to initial improved matrices for steps n° 2, 3 and 6.
- In the second round of the Delphi methodology, we emailed the improved matrices from the first round to the experts while requiring that they insert their opinions or improvements for each matrix. This led to the obtention of the final matrices thanks to the compromises that some experts have made following the feedback they received in the previous round.

For the purpose of providing concise results, only the final matrices emanating from the Delphi methodology are presented in the results section.

4. Results

In order to measure the organization's readiness for change for the implementation of an energy management system according to ISO 50001, the detailed steps of the described methodology in section 3 were followed. In this section, the obtained results are presented for each step.

The hierarchical model in Figure 1 was adopted for the first step, it comprises the goal of change readiness evaluation, as well as change readiness factors and subfactors, distributed hierarchically across three levels.

In the second step, a no-dependency hypothesis is considered among the framework's factors and subfactors. Relying on pairwise comparison matrices, the factors' and subfactors' local weights are determined. The Delphi method is used to reach a consensus among the participants. For level 1 factors, the obtained pairwise comparison matrix is displayed in Table A 0.1 of Appendix A. For level 2 factors, the obtained pairwise comparison matrices are presented in Tables: A 1.1, A 1.2, A 1.3, A 1.4 in appendix A. While the pairwise comparison matrices of level 3 factors are given in Tables B 1.1, B 1.2, B 1.3, B 1.4, B 1.5, B 1.6, B 1.7, B 1.8 in appendix B. The factors' and subfactor's local weights are then calculated using the steps of Chang's extent analysis method.

To better illustrate this step, an example of the local weight determination using Cheng's extent analysis will be provided for the case of the change context subfactor A11, based on the pairwise comparison matrix given in Table B 1.1, the fuzzy synthetic extent values are calculated using formula (1):

S_{A111}=(0.063, 0.111, 0.225)
S_{A112}=(0.063, 0.120, 0.243)
S_{A113}=(0.088, 0.180, 0.373)
S_{A114}=(0.118, 0.231, 0.409)
S_{A115}=(0.076, 0.158, 0.320)
S_{A116}=(0.103, 0.197, 0.373)

Then, using formula (3), the degrees of possibilities of a fuzzy extent analysis value being greater than another one are calculated:

$V(S_{111}\geq S_{112})$= 0.949 ; $V(S_{111}\geq S_{113})$= 0.666 ; $V(S_{111}\geq S_{114})$= 0.469 ; $V(S_{111}\geq S_{115})$= 0.759 ; $V(S_{111}\geq S_{116})$= 0.586
$V(S_{112}\geq S_{111})$= 1 ; $V(S_{112}\geq S_{113})$= 0.720 ; $V(S_{112}\geq S_{114})$= 0.526 ; $V(S_{112}\geq S_{115})$= 0.812 ; $V(S_{112}\geq S_{116})$= 0.643
$V(S_{113}\geq S_{111})$= 1 ; $V(S_{113}\geq S_{112})$= 1 ; $V(S_{113}\geq S_{114})$= 0.831 ; $V(S_{113}\geq S_{115})$= 1 ; $V(S_{113}\geq S_{116})$= 0.940
$V(S_{114}\geq S_{111})$= 1 ; $V(S_{114}\geq S_{112})$= 1 ; $V(S_{114}\geq S_{113})$= 1 ; $V(S_{114}\geq S_{115})$= 1 ; $V(S_{114}\geq S_{116})$= 1
$V(S_{115}\geq S_{111})$= 1 ; $V(S_{115}\geq S_{112})$= 1 ; $V(S_{115}\geq S_{113})$= 0.915 ; $V(S_{115}\geq S_{114})$= 0.734 ; $V(S_{115}\geq S_{116})$= 0.848
$V(S_{116}\geq S_{111})$= 1 ; $V(S_{116}\geq S_{112})$= 1 ; $V(S_{116}\geq S_{113})$= 1 ; $V(S_{116}\geq S_{114})$= 0.881 ; $V(S_{116}\geq S_{115})$= 1

Using formula (4), we calculate:

$V(S_{111}\geq S_{112}, S_{113}, S_{114}, S_{115}, S_{116})$= 0.469
$V(S_{112}\geq S_{111}, S_{113}, S_{114}, S_{115}, S_{116})$= 0.526
$V(S_{113}\geq S_{111}, S_{112}, S_{114}, S_{115}, S_{116})$= 0.831
$V(S_{114}\geq S_{111}, S_{112}, S_{113}, S_{115}, S_{116})$= 1
$V(S_{115}\geq S_{111}, S_{112}, S_{113}, S_{114}, S_{116})$= 0.734
$V(S_{116}\geq S_{111}, S_{112}, S_{113}, S_{114}, S_{115})$= 0.881

Finally, using formula (5), and after normalization, the local weight vector is obtained:

$$W = (0.469, 0.526, 0.831, 1, 0.734, 0.881)^T$$
$$= (0.106, 0.119, 0.187, 0.225, 0.165, 0.198)$$

Following this procedure, all factors and sub-factors' local weights are calculated. The obtained local weights are summarized in Table 5 (in the columns referring to level 1 local weights, level 2 local weights and level 3 local weights).

For the construction of the dependency matrix (step 3), the pairwise comparisons conducted are presented in Tables C 1.1, C 1.2, C 1.3, C 1.4 in appendix C. Using Chang's extent analysis method, the dependent weights are determined and constitute the dependency matrix displayed in Table C 1.5. The interdependent weights are then calculated by multiplying the dependence matrix and the obtained level 1 local weights (step 4). The results are displayed in the column corresponding to level 1 interdependent weights in Table 5.

In step 5, the subfactors global weights are calculated by multiplying the sub-factor's level 3 local weight with the interdependent weights of its corresponding 1st level factor and with the corresponding 2nd level local weight, the obtained global weights are given in the column referring to level 3 global weights in Table 5.

Using Cheng's linguistic variables in Figure 3, the evaluation of the factors and sub factors is carried out (step 6), the results are provided in the column corresponding to linguistic variables in Table 5. In step 7, for each subfactor, its global weight is multiplied with the fuzzy number corresponding to the given linguistic variable in the evaluation (in column scale value in Table 5), the obtained results are given in column GW*SV in Table 5. The global readiness for change maturity level is then identified by summing the results of the GW*SV column.

The obtained Maturity level ML= 0.578 refers to an average readiness for change maturity level regarding the adoption of an ISO 50001 based EnMS.

After calculating the expected average priority value for all sub-factors, the obtained average is 3.03% (1/33*100=3.030). This step will determine the most significant subfactors by only considering the ones with a value higher than the calculated expected average (twelve subfactors).

Table 5: Results of the FANP for criteria weighting and fuzzy based evaluation

Level 1 factors	Level 1 local weights	Level 1 interdependent weights	Level 2 subfactors	Level 2 local weights	Level 3 subfactors	Level 3 local weights	Level 3 global weights GW	Rank	Linguistic variable	Scale value SV	GW*SV
Change characteristics	0.140	0.159	Change context	0.316	Organizational politics	0.106	0.005	33	M	0.5	0.003
					Past experience	0.119	0.006	32	H	0.75	0.004
					Organizational climate and culture	0.187	0.009	30	M	0.5	0.005
					Policies and procedures	0.225	0.011	28	H	0.75	0.008
					Cohesion	0.165	0.008	31	M	0.5	0.004
					Discrepancy	0.198	0.010	29	M	0.5	0.005
			Change content	0.684	Organizational valence	0.500	0.054	5	M	0.5	0.027
					Appropriateness of the change	0.500	0.054	5	VH	1	0.054

Change capabilities	0.245	0.246	Structural factors	0.684	Knowledge	0.175	0.030	9	H	0.75	0.022
					Skills	0.175	0.030	9	H	0.75	0.022
					Ability alignment	0.175	0.030	9	H	0.75	0.022
					Organizational resources and structure	0.474	0.080	3	H	0.75	0.060
			Change agent's attributes	0.316	Perceived credibility	0.175	0.014	25	H	0.75	0.010
					Trustworthiness	0.175	0.014	25	M	0.5	0.007
					Sincerity	0.175	0.014	25	M	0.5	0.007
					Expertise	0.474	0.037	8	H	0.75	0.028
Change implementation process	0.367	0.341	Change readiness process	0.684	Attitudes of top management	0.558	0.130	1	M	0.5	0.065
					Management support	0.097	0.023	17	M	0.5	0.011
					Participation	0.345	0.081	2	M	0.5	0.040
			Change readiness communication	0.316	Discrepancy in the message	0.196	0.021	18	M	0.5	0.011
					Efficacy in the message	0.149	0.016	23	VL	0.0	0.000
					Appropriateness in the message	0.152	0.016	22	H	0.75	0.012
					Communication on principal support	0.129	0.014	24	VL	0.0	0.000
					Communication on valence	0.196	0.021	18	M	0.5	0.011
					Quality of change communication	0.177	0.019	21	M	0.5	0.010
Change recipients	0.248	0.253	Change recipient's individual factors	0.316	Values	0.331	0.026	15	M	0.5	0.013
					Self-efficacy	0.300	0.024	16	M	0.5	0.012
					Yield/ Personal valence	0.369	0.030	12	L	0.25	0.007
			Change recipient's organizational factors	0.684	Vision for change	0.233	0.040	7	H	0.75	0.030
					Organizational commitment	0.326	0.056	4	M	0.5	0.028
					Trust in leadership	0.121	0.021	20	M	0.5	0.010
					Collective efficacy	0.165	0.029	13	M	0.5	0.014
					Social relationships	0.155	0.027	14	M	0.5	0.013
Total											**0.578**

5. Discussion

From the obtained results, it appears that the subfactor with the highest importance (0.130) is the attitudes of top management. Indeed, among the barriers identified for a successful implementation, we find the low priority attributed to energy management (Cagno and trianni, 2014; Trianni, et al., 2016). Several studies have highlighted the importance of top management commitment and leadership in ensuring the continuity of the EnMS (Carbon trust, 2015; EDF Climate corps, 2015; Finnerty, et al., 2017), by providing the necessary resources to the implementation process and by creating cross-functional teams with an energy focus, with dedicated communication channels to surpass company silos (Fuchs, et al., 2020).

Participation of employees (0.081) is also considered a key component for a successful implementation, by involving employees in energy management (Jovanović and Filipović, 2016) and raising their awareness to the importance of their contribution through communication and transparency. Especially since cultural resistance and difficulty in employee education in energy related matters is a recurrent challenge for several companies (Fuchs, et al., 2020).

The third subfactor is the availability of the necessary organizational resources and structure (0.080), through procurement and investment (the availability of an energy information system and investment decision support) (Finnerty et al., 2017).

The fourth subfactor is organizational commitment (0.056), which is usually expressed through the communication on the organization energy policy (Finnerty et al., 2017) and drives all energy management efforts. A well-documented and communicated energy policy serves at clarifying the company's energy commitments and provides grounds for future accountability. Ensuring transparency in the communication of the achieved results is crucial to maintain the company's credibility.

On the fifth position, there are both organizational valence (0.054) and appropriateness of the change (0.054). Therefore, an internal communication on the advantages of the implementation of an EnMS and its appropriateness is essential to enhance these two factors, focusing on the expected benefits of the approach such as financial savings, the company's image, competitive advantage and improved operational efficiency (Finnerty, et al., 2017; Fuchs, et al., 2020; Karcher and Jochem, 2015). Especially since the Moroccan Agency for Energy Efficiency estimates energy savings from the adoption of an EnMS up to 25% (Moroccan Agency for Energy Efficiency, 2020).

For the seventh subfactor, the vision for change (0.040), it refers to a long-term energy strategy for the company and focuses on continuity, it is a driver for strategic energy initiatives (Finnerty et al., 2017). Having a vision that takes the national context into consideration is important to the perennity of energy related efforts. For instance, in 2019, a mandatory energy audits decree was adopted in Morocco. It concerns industries whose total final energy consumption exceeds 1500 tons of oil equivalent (toe) per year and the tertiary sector organizations that exceed 500 toe/ year. For the concerned industries or organizations, a declaration to the Moroccan Agency for Energy Efficiency is mandatory as well as the elaboration of an energy audit with a suitable action plan submitted to the same agency's approval. For organizations that already have a certified energy management system, they are exempt from the mandatory energy audit during the validity period of their certificate. This particularity of the Moroccan context has encouraged some companies towards the adoption of an energy management system, given that it is a standard that can easily be integrated within other management systems.

The following factors are expertise (0.037), knowledge (0.030), skills (0.030) ability alignment (0.030) and personal valence (0.030) which highlight the importance of training and investing in people (Finnerty et al., 2017). Especially since specific technical expertise is considered crucial for the success of the approach (Karcher and Jochem, 2015).

A final workshop was carried out, with all members of both focus groups, to share, present and discuss the obtained results, and to prepare for the construction of the pre-implementation improvement roadmap.

The discussions maintain that to achieve a better readiness for change for the implementation of the EnMS within this Moroccan factory, the organization will need to ensure the continuity of top management energy leadership and organizational commitment by actively participating in the system's review and appointing internal energy champions. According to the focus group, the challenge lies in the difficulty to communicate and coordinate cross-entities and top management has an essential role in ensuring and fostering effective communication channels (communication forums, collaborating platform, regular coordination and monitoring committees…).

Another improvement point revolves around the participation of employees, this can be achieved through continuous communication and transparency in sharing results, as well as, involving the employees by appointing energy use control assistants and internal energy champions across the organization, leading to the creation of an employee network to share and discuss energy related best practices. In addition to the organization of energy awareness campaigns and special energy related events (energy saving day, conferences, seminaries, energy challenge...) and the implementation of an energy suggestion bow within the factory to collect the employees' improvement ideas.

Finally, communication on personal and organizational valence should also be enhanced to improve employee's perceptions of the benefits of the approach, some participants hinted to the possibility to incorporate a symbolic financial sustainability bonus related to the achievement of the company's fixed energy objectives.

Based on the evaluation results and the different discussions regarding the readiness for the implementation of an Energy Management System within the factory, a pre-implementation improvement roadmap was elaborated to reduce potential failure risks prior to the project's launching, it is displayed in Table 6. The responsible actors for each action and the proposed deadlines are included within the initial proposed roadmap, however for relevance purposes, they are omitted in Table 6.

Table 6 Proposed pre-implementation improvement roadmap

Improvement factor	Proposed actions	Improvement key performance indicators
Top management attitudes	-Creating cross-functional teams with an energy focus. -Creating energy dedicated communication channels (periodic meetings, collaborative platform, communication forums, regular coordination and monitoring committees…).	-Number of held meetings per year. -Use rate of collaborative platforms.
Participation of employees	-Elaboration of an energy communication plan for sharing results and achievements and raising employee awareness. -Appointing energy use control assistants across the	-Number of communication actions per year

	organization and internal energy champions, this employee network will serve as a basis to share and discuss energy related best practices. -Planning of energy related events open to all employees (conferences, seminaries, annual energy day, energy challenge, …) -Implementing an energy suggestion box, for employees to propose energy-related improvements.	-Number of shared and identified best practices by the appointed energy use control assistants and internal energy champions annually. -Number of planned energy-related events per year -Number of ideas received through the suggestion box
Availability of the necessary organizational resources and structure	-Forecasting budget needs for energy actions (External expertise, energy information system….) -Definition of the Project's organization	-
Organizational commitment	-Raising awareness to the necessity to elaborate and communicate an energy policy, that formalizes the organization's commitments internally and externally.	-
Organizational valence	-Launching an internal communication campaign about the advantages of the implementation of the EnMS and its pertinence and appropriateness.	-Number of planned communication actions
Appropriateness of the change		
Vision for change	-Internal communication on the company's vision and goals through the implementation of the EnMS.	-
Expertise, knowledge, skills, ability alignment	-Planning for a global training program according to the required employee's needs (technical and operational, change-related, managerial...). -Clear separation of roles and responsibilities according to employee's abilities and profiles.	-Number of planned training actions -A well-defined and communicated RASCI matrix (Responsible, Accountable, Supporting, Consulted and Informed)
Personal valence	-Communication on the advantages that employees will gain from the program (training, experience, new roles…) -Exploring the possibility to include a symbolic sustainability financial bonus according to achieved results.	-

6. Conclusion

This study aims to develop a readiness for change maturity model that allows decision makers to determine the maturity of their organization regarding a planned change. Ensuring the readiness for change of the relevant stakeholders is essential for the success of any change initiative, since it generates supportive behaviors from employees and favors cooperativeness and persistence. The provided case study focused on the implementation of an energy management system according to the ISO 500001 standard within a Moroccan factory operating in the automotive sector. Contrary to the classical approaches that revolve around technical aspects, the organizational dimension was addressed from a readiness for change perspective. The proposed methodology is based on the Fuzzy Analytic Network Process with a linguistic variable-based evaluation along with a maturity model's approach. It has the benefit of considering the proposed factors' interdependencies and the human factor's inherent uncertainty and imprecision while providing clear conclusions to management. The obtained maturity level from the case study refers to an average readiness for change for the implementation of the Energy Management System within the studied factory and requires the definition of an improvement roadmap. The obtained results highlight the importance of top management attitudes, participation of employees, the availability of organizational resources and structures, organizational commitment, internal perceptions of the organizational valence and appropriateness of the change. These elements are essential for reaching a positive readiness for change across the organization. The limitations of this study concern the research and analysis of other change readiness factors such as cognitive and affective factors to enrich the proposed framework, as well as confronting the obtained results with post-implementation studies to assess the accuracy of the framework in practice. Future research could address the generalization potential of the proposed maturity model by conducting longitudinal studies, as well as exploring groups differences in terms of change readiness to conduct targeted improvement actions for the groups that display low readiness levels across the organization.

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Appendix A

This appendix contains the pairwise comparison matrices given a no-dependency hypothesis for level 1 and level 2 factors.

Table A 0.1 Pairwise comparison matrix relative to change readiness evaluation for level 1 factors

	A1: Change characteristics			**A2: Change capabilities**			**A3: Change implementation process**			**A4: Change recipients**		
A1: Change characteristics	1	1	1	0.5	0.67	1	0.5	0.67	1	0.5	0.67	1
A2: Change capabilities	1	1.5	2	1	1	1	0.4	0.5	0.67	0.67	1	2
A3: Change implementation process	1	1.5	2	1.5	2	2.5	1	1	1	1	1.5	2
A4: Change recipients	1	1.5	2	0.5	1	1.5	0.5	0.67	1	1	1	1

Table A 1.1 Pairwise comparison matrix relative to Change Characteristics

A1: Change characteristics	**A11: Change context**			**A12: Change content**		
A11: Change context	1	1	1	0.5	0.67	1
A12: Change content	1	1.5	2	1	1	1

Table A 1.2 Pairwise comparison matrix relative to change capabilities

A2: Change capabilities	**A21: Structural factors**			**A22: Change agent attributes**		
A21: Structural factors	1	1	1	1	1.5	2
A22: Change agent attributes	0.5	0.67	1	1	1	1

Table A 1.3 Pairwise comparison matrix relative to change implementation process

A3: Change implementation process	**A31: Change readiness process**			**A32: Change readiness communication**		
A31: Change readiness process	1	1	1	1	1.5	2
A32: Change readiness communication	0.5	0.67	1	1	1	1

Table A 1.4 Pairwise comparison matrix relative to change recipients

A4: Change recipients	**A41: Change recipients' individual factors**			**A42: Change recipients' organizational factors**		
A41: Change recipients' individual factors	1	1	1	0.5	0.67	1
A42: Change recipients' organizational factors	1	1.5	2	1	1	1

Appendix B

This appendix contains the pairwise comparison matrices given a no-dependency hypothesis for level 3 factors.

Table B 1.1. Pairwise comparison matrix relative to the change context factor A11

A11	A111			A112			A113			A114			A115			A116		
A111	1	1	1	0.67	1	2	0.5	0.67	1	0.4	0.5	0.67	0.5	0.67	1	0.4	0.5	0.67
A112	0.5	1	1.5	1	1	1	0.5	0.67	1	0.4	0.5	0.67	0.67	1	2	0.4	0.5	0.67
A113	1	1.5	2	1	1.5	2	1	1	1	0.67	1	2	0.67	1	2	0.5	1	1.5
A114	1.5	2	2.5	1.5	2	2.5	0.5	1	1.5	1	1	1	1	1.5	2	1	1.5	2
A115	1	1.5	2	0.5	1	1.5	0.5	1	1.5	0.5	0.67	1	1	1	1	0.67	1	2
A116	1.5	2	2.5	1.5	2	2.5	0.67	1	2	0.5	0.67	1	0.5	1	1.5	1	1	1

With:
A111: Organizational politics
A112: Past experience
A113: Organizational climate and culture
A114: Policies and procedures
A115: Cohesion
A116: Discrepancy

Table B 1.2. Pairwise comparison matrix relative to the change content factor A12

A12	A121			A122		
A121	1	1	1	0.5	1	1.5
A122	0.67	1	2	1	1	1

With:
A121: Organizational valence
A122: Appropriateness

Table B 1.3 Pairwise comparison matrix relative to structural factors A21

A21	A211			A212			A213			A214		
A211	1	1	1	1	1	1	1	1	1	0.5	0.67	1
A212	1	1	1	1	1	1	1	1	1	0.5	0.67	1
A213	1	1	1	1	1	1	1	1	1	0.5	0.67	1
A214	1	1.5	2	1	1.5	2	1	1.5	2	1	1	1

With:
A211: Knowledge
A212: Skills
A213: Ability alignment
A214: Organizational resources and structure

Table B 1.4. Pairwise comparison matrix relative to change agent attributes A22

A22	A221			A222			A223			A224		
A221	1	1	1	1	1	1	1	1	1	0.5	0.67	1
A222	1	1	1	1	1	1	1	1	1	0.5	0.67	1
A223	1	1	1	1	1	1	1	1	1	0.5	0.67	1
A224	1	1.5	2	1	1.5	2	1	1.5	2	1	1	1

With:
A221: Perceived credibility
A222: Trustworthiness
A223: Sincerity
A224: Expertise

Table B 1.5. Pairwise comparison matrix relative to change readiness process A31

A31	A311			A312			A313		
A311	1	1	1	1.5	2	2.5	1	1.5	2
A312	0.4	0.5	0.67	1	1	1	0.5	0.67	1
A313	0.5	0.67	1	1	1.5	2	1	1	1

With:
A311: Attitudes of top management
A312: Management support
A313: Participation

Table B 1.6. Pairwise comparison matrix relative to change readiness communication A32

A32	A321			A322			A323			A324			A325			A326		
A321	1	1	1	1	1.5	2	1	1.5	2	1	1.5	2	1	1	1	0.5	1	1.5
A322	0.5	0.67	1	1	1	1	0.67	1	2	1	1	1	0.5	0.67	1	0.67	1	2
A323	0.5	0.67	1	0.5	1	1.5	1	1	1	0.67	1	2	0.5	0.67	1	0.67	1	2
A324	0.5	0.67	1	1	1	1	0.5	1	1.5	1	1	1	0.5	0.67	1	0.5	0.67	1
A325	1	1	1	1	1.5	2	1	1.5	2	1	1.5	2	1	1	1	0.5	1	1.5
A326	0.67	1	2	0.5	1	1.5	0.5	1	1.5	1	1.5	2	0.67	1	2	1	1	1

With:
A321: Message discrepancy
A322: Message efficacy
A323: Message appropriateness
A324: Communication on principal support
A325: Communication on valence
A326: Quality of change communication

Table B 1.7. Pairwise comparison matrix relative to change recipients' individual factors A41

A41	A411			A412			A413		
A411	1	1	1	0.5	1	1.5	0.67	1	2
A412	0.67	1	2	1	1	1	0.5	0.67	1
A413	0.5	1	1.5	1	1.5	2	1	1	1

With:
A411: values
A412: Self-efficacy
A413: Yield or personal valence

Table B 1.8. Pairwise comparison matrix relative to change recipients' organizational factors A42

A42	A421			A422			A423			A424			A425		
A421	1	1	1	0.5	0.67	1	1	1.5	2	0.5	1	1.5	1.5	2	2.5
A422	1	1.5	2	1	1	1	1.5	2	2.5	1.5	2	2.5	1.5	2	2.5
A423	0.5	0.67	1	0.4	0.5	0.67	1	1	1	0.67	1	2	0.5	0.67	1
A424	0.67	1	2	0.4	0.5	0.67	0.5	1	1.5	1	1	1	0.5	1	1.5
A425	0.4	0.5	0.67	0.4	0.5	0.67	1	1.5	2	0.67	1	2	1	1	1

With:
A421: Vision for change
A422: Organizational commitment
A423: Trust in leadership
A424: Collective efficacy

Appendix C

This appendix contains the pairwise comparison matrices necessary for the construction of the dependency matrix

Table C 1.1. Pairwise comparison matrix relative to change characteristics A1

Change characteristics	Change capabilities			Change implementation process			Change recipients		
Change capabilities	1	1	1	0.4	0.5	0.67	0.67	1	2
Change implementation process	1.5	2	2.5	1	1	1	1	1.5	2
Change recipients	0.5	1	1.5	0.5	0.67	1	1	1	1

Table C 1.2. Pairwise comparison matrix relative to change capabilities A2

Change capabilities	Change characteristics			Change implementation process			Change recipients		
Change characteristics	1	1	1	0.5	0.67	1	0.5	0.67	1
Change implementation process	1	1.5	2	1	1	1	1	1.5	2
Change recipients	1	1.5	2	0.5	0.67	1	1	1	1

Table C 1.3. Pairwise comparison matrix relative to change implementation process A3

Change implementation process	Change characteristics			Change capabilities			Change recipients		
Change characteristics	1	1	1	0.5	0.67	1	0.5	0.67	1
Change capabilities	1	1.5	2	1	1	1	0.67	1	2
Change recipients	1	1.5	2	0.5	1	1.5	1	1	1

Table C 1.4. Pairwise comparison matrix relative to change recipients A4

Change recipients	Change characteristics			Change capabilities			Change implementation process		
Change characteristics	1	1	1	0.5	0.67	1	0.5	0.67	1
Change capabilities	1	1.5	2	1	1	1	0.4	0.5	0.67
Change implementation process	1	1.5	2	1.5	2	2.5	1	1	1

Table C 1.5. Dependency matrix

	A1: Change characteristics	A2: Change capabilities	A3: Change implementation process	A4: Change recipients
A1: Change characteristics	1.000	0.207	0.237	0.161
A2: Change capabilities	0.251	1.000	0.381	0.293
A3: Change implementation process	0.501	0.450	1.000	0.546
A4: Change recipients	0.248	0.343	0.381	1.000

变革准备成熟度模型的开发：能源管理系统实施案例研究

關鍵詞
能源管理系统
ISO 50001
改变准备
成熟度模型
模糊分析网络过程

摘要
本文提供了一种基于使用模糊分析网络过程和模糊语言评估成熟度模型来评估组织变革准备成熟度的方法。这种预期方法的目的是评估组织准备实施变革计划的程度，以便在实施变革之前增强支持性行为并确定改进领域，从而降低变革采用失败的风险。提供了根据 ISO 50001 标准在汽车行业工厂实施能源管理系统的案例研究。与能源管理成熟度模型中的经典技术方法不同，这种方法提供了组织视角。使用模糊分析网络过程可以考虑因素之间的相互关系，而使用模糊逻辑通过语言变量进行评估有助于考虑受访者的不确定性和不精确性。这种方法通过提供组织的准备成熟度水平以及有助于确保成功实施所需变革计划的改进领域的识别，为决策者提供决策支持系统。在所进行的案例研究中，获得的成熟度水平是指为实施能源管理体系而进行变革的平均准备程度，需要定义改进路线图，包括以下要素：确保最高管理层的领导和组织承诺，以及让员工参与以及关于实施能源管理系统的个人和组织利益的内部沟通。