PEER-REVIEWED PAPER

Improving industrial energy efficiency by changing the energy culture

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Abstract

In recent years there have been several studies showing that behavioral change can contribute to savings of 5–15 % of the energy consumption of an industrial site. This was confirmed in a survey in 2011[1] of the Belgian and Dutch industry showing that behavioral change is both an opportunity and a challenge to achieve energy efficiency.

The Energy Culture of an organization is the shared mindset that creates and sustains an environment leading to continual improvement of the energy performance of the organization. It is focused on the behavior of the people of an organization and their impact on the energy use.

In this paper, we will show how significant energy savings can be achieved by changing behavior. The first step is an assessment of the Energy Culture of an organization. This evaluation is based on eight different dimensions: Visibility, Accountability, Collaboration, Targeting, Commitment, Motivation, Learning and Progress, and is executed using a combination of data analysis, surveys, interviews and workshops. Once the assessment is completed, it is possible for an organization to develop an action plan to improve whatever dimension or combination of dimensions they want to focus on. Noted that often work on one dimension has positive effects on several dimensions simultaneously.

A case study will be presented were this approach was implemented at a chemical manufacturer. The result from the assessment was used to develop an action plan and this plan has now started to be implemented.

Introduction

Despite the efforts made over the last 20 years, research suggests that there remains an important potential to reduce energy consumption in energy intensive industry by 15–25 %[2,3]. The same research indicates that energy management and behavioral changes can achieve up to 47 % of this remaining energy efficiency potential. Several articles also show that only a limited number of companies actually focus on managing energy[4,5]. Often, the main reasons given for not managing energy is lack of time, lack of resources, focus on production, focus on safety and that energy is not a focus area.

Energy use is strongly linked to greenhouse gas (GHG) emissions, as the requirement for GHG reduction is likely to increase with increased requirements from the European Com-

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2. Jollands, N., Tanaka K., Gasc, E., Wescott, W., "Energy Management Action NetworK (EMAK)-A scoping study investigating the establishment and support of an international and domestic action network of energy management in industry", International Energy Agency, France, 2009.

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mission, it is probable that there will be increased pressure on industry to reduce their energy consumption. Managing energy could be a big contributor helping industry reduce their emissions. In addition it might also become a strong driver to stay competitive if the energy prices continue to rise.

Managing energy is a management question and linked to behaviors rather than a technical solution. Literature suggests that contextual factors such as corporate culture and investment strategies, may present strong inertial forces within organizations that inhibit implementations that appear technically rational[6]. But just like the car manufacturing industry had to revolutionize their way to make cars in order to improve quality, manufacturing industry will likely have to change their behaviors with regards to energy. With regards to energy, the combination of these factors; people, systems, structure, skills and strategy, is referred to as an organization's Energy Culture.

In this paper a new methodology will be presented that has been developed for the energy intensive manufacturing industry. It draws inspiration from behavioral models and theories of change and is a comprehensive approach to assess and improve an organization's Energy Culture and thereby reduce its energy costs. A case study where this methodology has been applied will be shown and there will be a discussion to conclude.

Behavioral change theory

Behavioral change theory has two distinct parts; models of behavior and theories of change[7]. Models of behavior help us understand specific behaviors and their underlying factors that influence them. Theories of change are models that show how behaviors change over time. Both parts are complementary and equally important in order to develop an effective methodology to behavior change.

Models of behavior are based on a number of key elements such as threat, fear, response efficacy, self-efficacy, barriers, benefits, subjective norms, attitudes, intentions, cues to action, habits and reactance[8]. Attitude seems to be the most essential factor in most models of behavior. In order to be the most effective, our methodology, presented later in the paper, incorporates most of these key elements.

For theories of change, our approach is inspired by Kotter's 8-step process for leading change[9]. Kotter's 8-step process includes the following steps; Establishing a sense of urgency, Creating the guiding coalition, Developing a change vision, Communicate the vision for buy-in, Empowering broad-based action, Generating short-term wins, Never letting up and Incorporating changes into the culture. Kotter's 8-step process seems to be similar to the Trans theoretical (Stages of Change) model[10]. The Trans theoretical model is classified as a so-called staged model and defines behavior change as a process that unfolds over time involving progress through a number of stages. In the Trans theoretical model, these stages are precontemplation, contemplation, preparation, action, maintenance, and termination.

If looking at Kotter's 8-step process, it is possible to place the 8-steps into the Trans theoretical 6-stage model. The precontemplation stage is where people are starting to become aware that there are possible changes in the future and that others are changing; this would be a step happening before Kotter's 8-step process. The contemplation stage is where people intent to change and this is where Kotter's "Establishing a sense of urgency" step most likely would fall into. Preparation is the stage where people intend to take action and is preparing a plan, Kotter's "Creating the guiding coalition" and "Developing a change vision" could fit into this stage. Action is the stage where the behavior change happens, Kotter's "Communicating the vision for buy-in", "Empowering broad-based action" and "Generating short-term wins" could fall into this stage. Maintenance is where people work to prevent relapse, this would be Kotter's "Never letting up". Finally the termination stage is the stage where the behavioral change is so ingrained in the culture that there are no relapses. This stage would represent Kotter's "Make it stick" step. This is the most difficult stage to maintain and as Kotter also notes "Changes – whether consistent or inconsistent with the old culture – are difficult to ingrain". Often the behavioral changes needs consistent maintenance and stay in the maintenance stage for a long time if not indefinitely.

Approach

The combination of behavior models and change theories is the basis for the methodology presented here. In order to assess the current status of an organization, it is evaluated on eight different dimensions covering the key elements in behavior models. The eight dimensions are: Visibility, Accountability, Collaboration, Targeting, Commitment, Motivation, Learning and Progress.

THE EIGHT DIMENSIONS

Visibility falls under the key element "cues to action". It could also be called a contextual factor that rarely is included in behavioral models as it is an external factor, beyond an individual's control[11]. The strategy to change behavior under "cues to action" is to provide information that might trigger individuals to make decisions. If a person performing a task does not have the necessary information available, they will not include that information into their decision and consequent action. It is important to note that the use of information provided heavily depends on how an individual perceives them.

Accountability is part of "subjective norms" that is what an individual perceives that most people who are important to him think that he should or should not do and "fear" which is the perceived threat[12]. Rules, laws and regulation would also fall into such a combination, replacing "people that are important to him" with the society and the legal framework and "fear" with the perceived threat of legal consequences. In companies

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accountability is an important base on which the company functions. "People that are important to him" are replaced by manager and supervisors and the "fear" corresponds to the perceived threat of being reprimanded, demoted or fired.

Collaboration also falls under the key element "cues to action". The idea behind collaboration is the sharing of ideas that would increase an individual's knowledge and information that would then trigger the correct action. It also falls under the key element "self-efficacy" as collaboration could increase an individual's sense that they can carry out an action successfully.

Targeting is part of "response efficacy" but only in combination with recommendation for corrective action.[13] Providing a series of recommended responses and evidence that shows that those responses will avert the negative threat should be integral part of effective targeting.

Commitment is part of "intentions" that is, an individual's commitment to perform a specified behavior. It is also a form of consistency of behavior that is derived from cognitive dissonance theory. Cognitive dissonance theory suggests that individuals have a need to keep attitudes and beliefs in harmony.[14] Conflicting thoughts often create internal discomfort, which motivates behavior that will restore balance. An extension of cognitive dissonance theory is that commitments set the stage for subsequent consistent behavior and thus can play an important role in changing behavior.[15]

Motivation is used to refer to our reasons for action and to our enthusiasm to do so and is very closely linked to the key element "benefits"[16]. The benefits can be of different form such as recognition, achieving goals and monetary rewards. Motivation is also linked to "subjective norms" and "attitudes" for example what an individual thinks that other people think that they should do (subjective norm) and an individual's evaluation or believe about a recommended response (attitudes)[17].

Learning is linked to the key element of "self-efficacy". Just like collaboration, learning is a way to gain confidence in an individual's ability to perform a certain action or task[18].

Progress is linked to "response efficacy" where there is a perception that a certain response will prevent a threat to happen. Group efficacy is positively related to effectiveness when uncertainty is low so progress is also a measure of uncertainty.[19]

ASSESSMENT

These eight dimensions are evaluated using a combination of tools such as surveys, interviews, workshops and observations. They are not just evaluated to get a better understanding of an organization's behavioral model and ability to change but also to understand what tools have already been implemented in the organization and what tools could still be used to promote change. They are also used to identify what are the barriers to energy efficiency.

In each of the eight dimensions, an organization's performance is expressed as a maturity level.

Table 1 contains some examples of the typical conditions to which the different levels correspond. As can be seen both systems and behavioral aspects are listed. In many cases the conditions cover multiple dimensions. This is also true for the actions that are implemented to improve a specific dimension. In other words, most improvement actions will have an impact on multiple dimensions.

The result of the evaluation is presented as a spider diagram. An example of such a spider diagram can be seen in Figure 1, where three different levels of maturity are shown expressed by the three different lines. Using a spider diagram, it is visual way to quickly see where the biggest potential for improvement lays.

ACTION PLAN

After the assessment, an action plan is developed in order to improve the Energy Culture. When referring to Kotter's 8-step approach, the action plan can cover steps 1–7, anything from "Establishing a sense of urgency" to "Never letting up". Typically, the first four steps, "Establish a sense of urgency", "Creating the guiding coalition", "Developing a change vision" and "Communicating the vision for buy-in", are activities that are running in parallel to the assessment phase. "Empowering broad-based action" and "Generating short-term wins" are very important steps of the action plan and should preferably happen early in the process to remove barriers and generate momentum. Considering this, an action plan is developed for 12–24 months. This action plan also depends on the organization's maturity level displayed above, its ambition, commitment and budget. Based on the different dimensions and their behavioral model, different systems and actions are recommended to be implemented and part of the action plan. Examples of this can be seen in Table 2.

Case study

This methodology was implemented at a chemical plant mainly producing silicones and their derivatives. The site employs around 700 people working in both administrative, research and operational roles. The site had already realized many energy efficiency projects as well as fuel switching to achieve GHG reductions. They had identified behavioral change as an opportunity to achieve even further energy savings and GHG reductions. As a first step to that, they had started to implement energy metering in order to be able to track their energy performance in real-time.

The first step of the project was to assess their Energy Culture. Two different surveys were sent out, one for the personnel in the manufacturing process and one to administrative, R&D and laboratory personnel as their daily work significantly differs. The members of the management committee were interviewed and workshops were held with both engineers and operators.

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Table 1. Maturity levels.

N°	Maturity Level	Examples
1	Inert	No or limited information on energy performance is available. There is no energy related training provided.
2	Reactive	Energy is measured via on-site utility meters only, which are recorded manually at irregular/long intervals. Poster campaigns are organized to generate awareness.
3	Involved	Part of management bonuses are based on energy performance. Plant wide energy performance is illustrated on screens and/or boards throughout the facility.
4	Proactive	Energy use of main energy users is measured in real-time and automatically analyzed and stored. A self-assessment process is carried out by energy champions on a regular basis.
5	Continually improving	A comprehensive and real-time metering structure is in place, covering both main energy users and main energy drivers. Energy performance is discussed on a daily basis at all level of the organization.

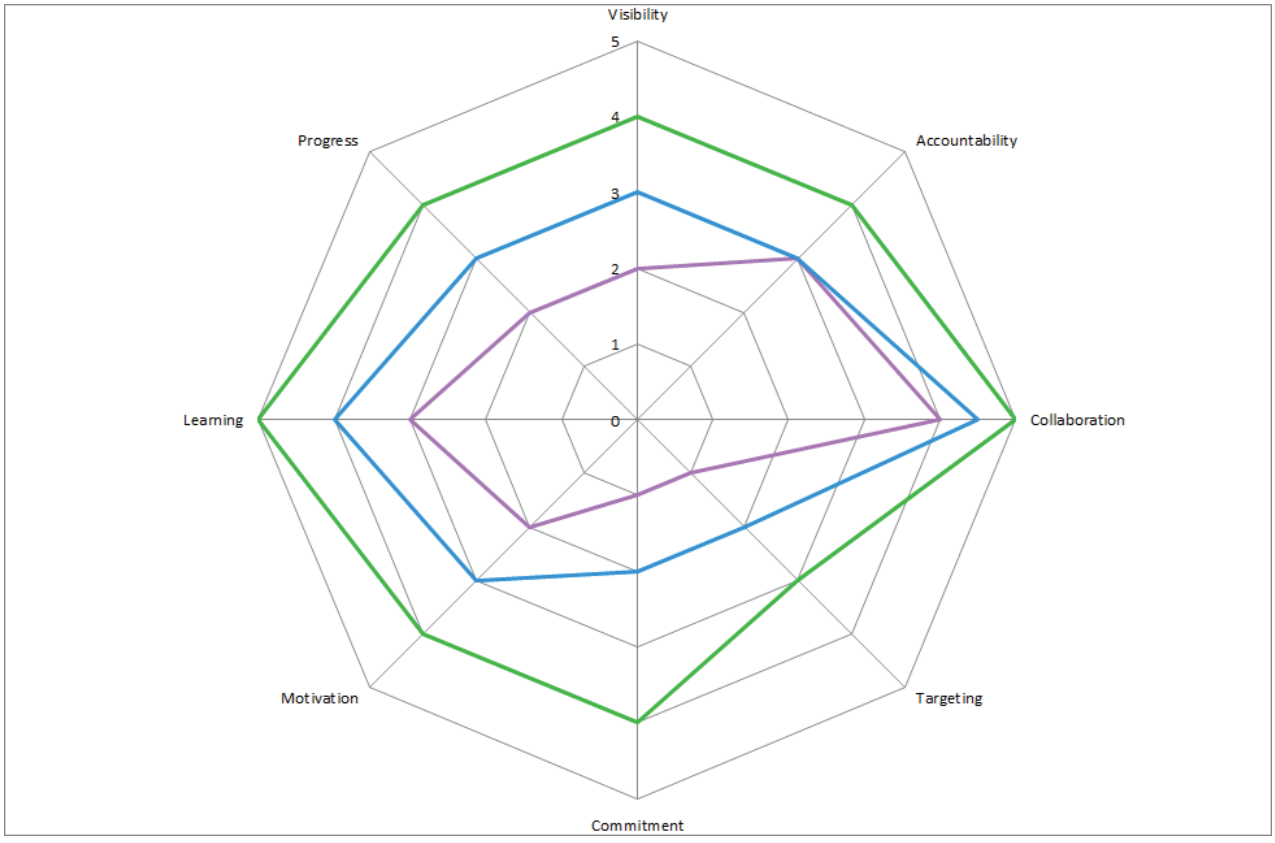

Figure 1. Spider diagram.

Table 2. Recommended actions.

Dimension	Examples
Visibility	Cues to action: Make energy reports available to all employees. Incorporate energy Key Performance Indicators (KPI's) in management/ governance system.
Accountability	Subjective norms and fear: Give each energy KPI an owner. Assign actions to people and follow-up.
Collaboration	Cues to action and self-efficacy: Create cross-functional team that work on energy performance issues. Have energy manager from different departments meet on a regular basis.
Targeting	Response efficacy: Implement dynamic targets on all energy drivers and KPI's. Put systems in place to identify reasons for drift from normal operation.
Commitment	Intentions: Make sure that management is lead by example. Collect and implement energy improvement ideas.
Motivation	Benefits: Implement incentive programs for all employees linked to energy. Link bonuses to energy efficiency performance.
Learning	Self-efficacy: Create a know-how retention program. Highlight and communicate all energy initiatives.
Progress	Response efficacy and uncertainty: Implement a comprehensive energy metering system. Create a continuous improvement group focused on energy.

SURVEYS

The two different surveys each had a number of questions related to each one of the dimensions. Examples of questions can be seen in Table 3.

The response rate for the survey was 40 % and served as the main input to the spider diagram.

INTERVIEWS

The 11 members of the management committee were interviewed. The interviews were used to corroborate and complement the results of the surveys. In particular, non-technical barriers were identified during the interviews that would have been difficult to identify through the surveys such as communication challenges between engineers and operators. The interview template followed the same type of format as the survey with questions for each one of the dimensions. Mostly open questions were used, as quantitative data already was available through the two surveys. The results of the interviews validated the spider diagrams from the survey and served as the main input parameter to the recommendation in the action plan for the change process.

WORKSHOPS AND OBSERVATIONS

Five different workshops were held, two with personnel from the engineering department and three with operators from production. The main purpose of the workshop was to observe a group discuss the variability of energy use on a specific installation. Results from the surveys were further corroborated and both technical and non-technical barriers to the change process were identified. In addition a list of so-called quick-wins was established. Quick-wins are ideas of improvements that could be implemented quickly and help create a momentum in the change process. They require little or no investment and are a first step of capturing the gains associated with an organization's Energy Culture. In addition to workshops, observations were made in the different control rooms in the production facilities. These again helped corroborate survey results as well as helped understand how personnel perform their duties and how energy could be incorporated in those duties. The observation also helped to get a better understanding of existing tools that could be used to facilitate the implementation phase.

RESULTS

In Figure 2 the resulting spider diagram can be seen. Visibility was a particularly weak dimension. This had already been identified by the organization and actions to improve visibility had already started. Commitment was their strongest dimension and that was seen throughout the study. Results from surveys, interviews, workshops and observations corroborated the high score for commitment. This is an important factor for the change process as well, as change take time and endurance.

Table 3. Example questions.

Dimension	Example question
Visibility	Do you have real-time information regarding your equipment's energy use? a) Yes b) No c) I don't know
Accountability	Is there an energy manager onsite? a) Yes b) No c) I don't know
Collaboration	Is there a forum to discuss energy? a) Yes b) No c) I don't know
Targeting	Is energy performance measured and reported in the same way as production/quality? a) Yes b) No c) I don't know
Commitment	Do you know if there is a company energy policy? a) Yes b) No
Motivation	Is there an improvement box where you can put your ideas for energy efficiency improvement? a) Yes b) No c) I don't know
Learning	Have you received any energy training? a) Yes b) No
Progress	Is there a continuous improvement group within the company? a) Yes b) No c) I don't know

An action plan was developed as well and examples from that action plan can be seen in Table 4. This is illustrated as well in the spider diagram in Figure 3, where the projected levels for each dimension are shown for the two scenarios; ambitious and challenging. The ambitious scenario aims at increasing the dimensions' scores about half a point and the challenging scenario one point.

The organization is just starting to implement the action plan. The project has already created momentum in the organization and the action plan aims at supporting the momentum for sustainable long-term gains. Metering is starting to be implemented. Once that is completed, the quantitative results from implementing the action plan can be measured. The action plan also supports Kotter's 8-step process, where the first six steps are included in the action plan. The remaining two steps are the maintaining step of never letting up and the final step where the change has been incorporated in the corporate culture.

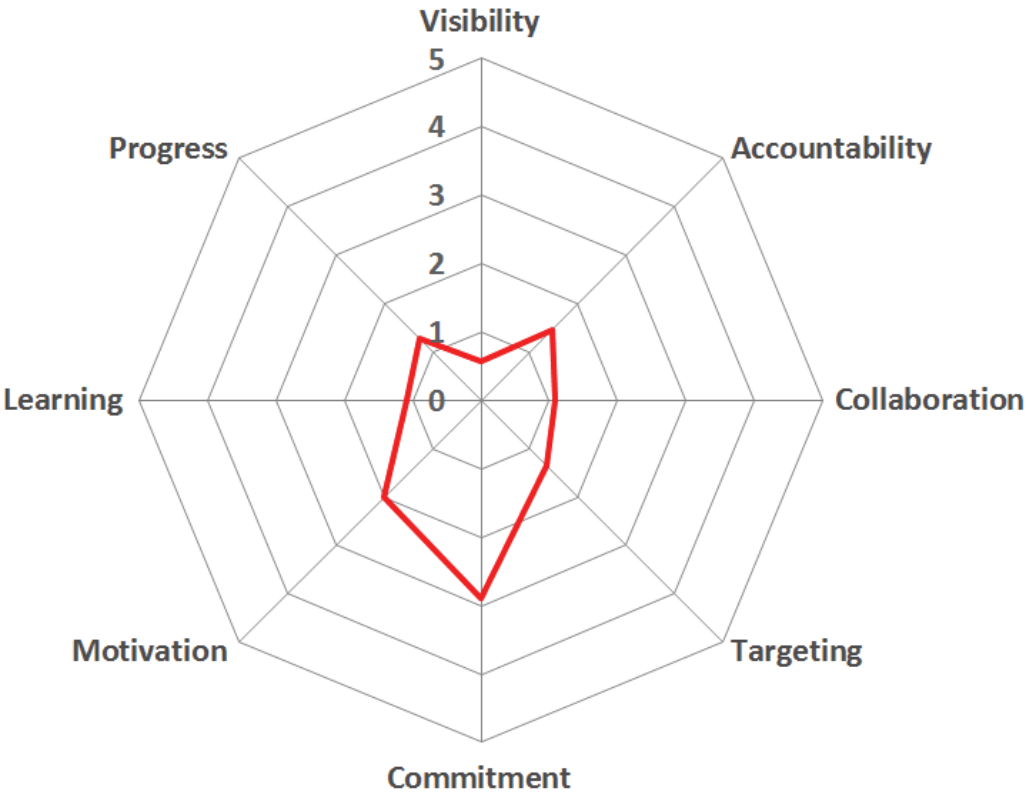

Figure 2. Result spider diagram.

Table 4. Examples from action plan.

Scenario	0–6 months	6–12 months	12–18 months	18–24 months
Ambitious	Create a vision to change energy culture. Identify quick-wins. Identify energy champions in main areas.	Develop an optimal KPI structure from the bottom-up with roles and responsibilities. Create quick-wins. Develop baselines for main energy users.	Set targets for KPI structure. Re-launch a poster campaign with figures related to energy savings. Develop or update standard operating procedures.	Develop an incentive program including ideas collection, analysis, selection and implementation. Identify best practices in targeted department.
Challenging	Develop an action plan to achieve the targets of the energy policy.	Develop a continuous improvement group focused on energy.	Develop dynamic targets for KPI structure.	Develop a bonus program that considers energy use.

Discussion

This paper has presented the foundation, specification, and validated application of a generalized methodology to assess and improve an organization's Energy Culture. It is a novel approach that draws inspiration from both behavioral models and theory of change. It covers many of the key elements of behavioral models and is thus a comprehensive approach to behavioral change in industry. The case study showed the application of the methodology in a chemical plant where the momentum for change has started and is moving forward following the principals of this methodology. Follow-up work with the plant will evaluate the progress and estimate the specific energy and CO_2 savings. Future work will include methodologies on how to measure the potential for behavioral change before starting the project and additional case studies to show quantitative savings.

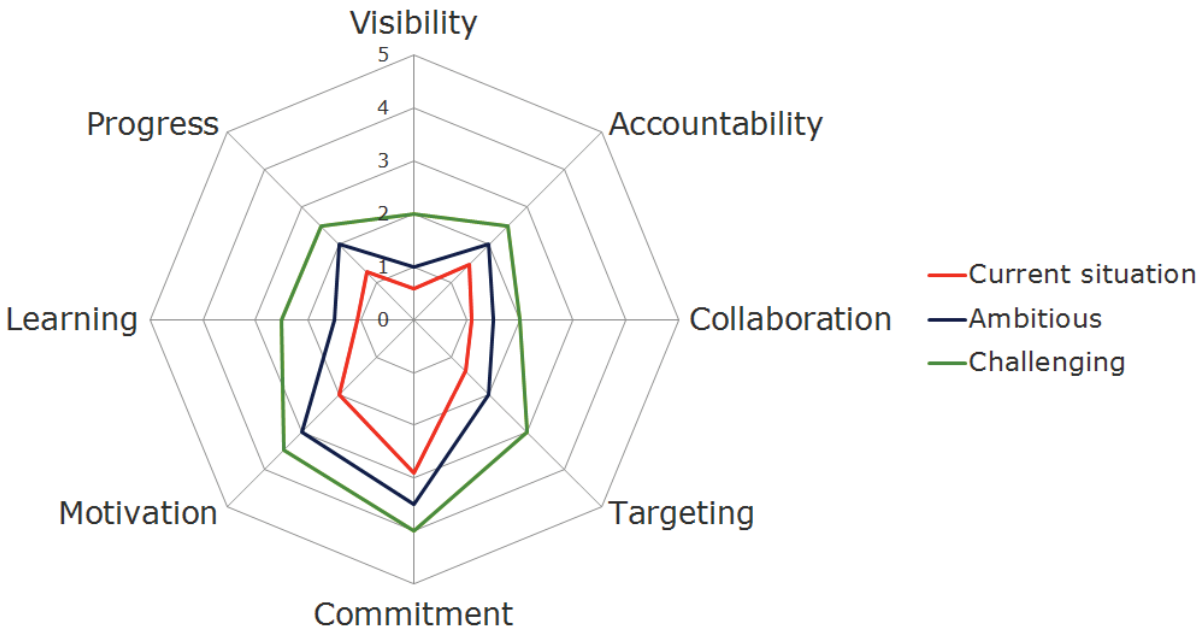

Figure 3. Targeted levels with the action plan.

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