



Toward developing key performance indicators for desalination processes

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ABSTRACT

Key performance indicator (KPI) is a discipline that involves articulating what an organization is trying to accomplish and afterward identifying the most meaningful and useful indicators of success. KPI is a key part of a strategic management system. Noteworthy KPIs provide information into whether strategies are working, and programs, objectives and goals are accomplished. In this work, KPIs principles will be reviewed. Then the strategic objectives and goals for operating desalination plants in effective manner will be utilized to develop viable strategic plan, set initiatives and programs to achieve certain objectives and goals in the field of water desalination. Operational performance measures will be used to identify the applicable and appropriate KPIs. KPIs for water desalination plants are convenient tools in assisting to manage practical operation of the plants.

Keywords: Performance; Metrics; Key performance indicators; Performance indicators; Strategic plan; Water strategic plans; Desalination

1. Introduction

Key performance indicators (KPI) focus on the aspects of organizational performance that are the most critical for the current and future success of the organization [1]. KPI can be defined as a measurable value that is used to demonstrate how effectively strategic goals or objectives are achieved.

According to the Intrafocus Guide, a key performance indicator may be counted, compared and provided evidence that an objective is being attained over a specified time [2]. These key words are explained in the Intrafocus Guide as follows [2];

Counted: This may seem a little trite, however, counted means that a quantity can be assigned. Examples of quantity are number, percentage or currency. It does not mean a percentage achievement. One of the most frequent mistakes in setting KPIs is to create a project and assess its success through how much work has been done. Just because a project has been completed does not mean it has been

a success. Success is dependent on the outcome not the activity.

Compared: A number or value may be interesting, but it only becomes useful when it is compared to what is optimal, acceptable or unacceptable. Every KPI must have a comparator or benchmark. Using an industry benchmark gives an objective quality to the comparator, objectivity is not required, but it is desirable.

Evidence: The evidence will fall out by 'counting' and 'comparing' correctly. It is important to strive for a measure that will be observed in the same way by all stakeholders. The evidence should be clear and have specific meaning.

Objective: A KPI only has significance if it is contributing to an objective. If there is no objective, why is it being measured in the first place? This does not mean we should ignore all operational measures; they still need to be in place – but even operational measures should ultimately contribute to an objective.

Specified time: Everything is time bound; progress towards meeting an objective and therefore a strategy must be measured over a specified period.

The term indicator must comprise some basic requirements, such as [3]:

- indicators should represent targets effectively,
- they should be simple and easy to interpret,
- they should be able to indicate time trends,
- they should “respond” to changes within or outside the organization,
- the relevant data collection and data processing should be easy,
- they should be updated easily and quickly.

KPIs provide the most important performance information that enables organizations or their stakeholders to understand whether the organization is on track toward its stated objectives or not [4]. In addition, KPIs serve to reduce the complex nature of organizational performance to a small, manageable number of key indicators that provide evidence that can in turn assist decision making and ultimately improve performance.

KPIs should enable the organization to identify the criteria against which it can measure its performance against each strategic priority, which match up to the organization’s long-term objectives. KPIs will determine the extent to which the strategies have been achieved. KPIs are measures that provide some feedback on performance. They should be related to the strategies and could include quality, quantity and time components. Other benefits of having KPIs are as follows [5]:

- Serve as a communication tool to keep individuals within an organization up to date with the group’s progress or performance.
- Provide a self-explainable snapshot of the performance against the set objectives.
- Encourage and establish responsibility and accountability.
- Support the organization strategic goals.
- Constitute a transparent tool to view and communicate the organization performance at all levels.
- Objectively measure individuals and business units’ contributions.
- Unite or align individuals and teams towards a common goal.
- Highlight opportunities for improvement and strengths.
- Encourage competitively and initiative.
- Promote consistency, continuity, and continuous improvement.
- Can enable an organization to gain a competitive advantage when they are set wisely.

Successful KPIs rely on effective objectives and goals. Objectives and goals need to be SMART to be effective. SMART stands for specific, measurable, achievable, relevant, and time-bound, such as:

- Specific (simple, sensible, significant).
- Measurable (meaningful, motivating).
- Achievable (agreed, attainable).
- Relevant (reasonable, realistic, and resourced, results-based).
- Time bound (time-based, time limited, time/cost limited, timely, time-sensitive).

In this regards, KPI serves as a convenient tool in assisting to manage practical operation of the desalination plants. So operational performance measures will be used to identify the applicable and appropriate KPIs for water desalination plants. This will be performed after the development of viable strategic plan based on setting initiatives and programs to achieve certain objectives and goals in the field of water desalination.

2. Development of strategic plan

The basic aim of strategic planning is to establish definitively the nature and character of an organization and the sector that it represents and to manage its future development [6]. Within the strategic planning process, goals, priorities and strategies are established and the measures needed to evaluate the success of these goals are defined. So a strategic plan represents an integrated set of strategic goals and operational objectives and activities needed to achieve a desired result (often defined as an organization’s “mission” or “vision”) [6].

The characteristics of strategic planning may be defined as follows [6].

It considers the environment in which an institution operates: strategic planning relies largely on the results of an external analysis of the environment in which an organization operates and which the organization has very little influence over. Different environmental factors, such as demographic trends, the macro-economic situation, political trends, social tendencies, etc., may have a decisive impact on the organization’s results.

Provides a mid-term framework for the organization’s operations: The strategic plan is, amongst other things, developed in order to maintain the continuity and consistency of an organization’s activities. This leads to the development of a plan with the longest possible timeframe. At the same time, constant changes within the environment require flexibility, whereas long-term planning reduces the precision of a plan. Thus, three to 5 y represents a good option for a strategic plan timeframe.

It is a dynamic process: Due to the fact that the environment is ever changing and that it is very difficult to forecast future events, planning is a continuous process. Consequently, adjustment of the plan to new circumstances within the environment has to be done on an annual basis.

It is the basis for the allocation of resources: The strategic planning process has to be integrated within the budgetary planning process in order for a plan to be feasible. In this way, the final allocation of resources reflects the selected priorities that contribute to the development of the sector for which it is responsible.

The major difference between strategic planning and long-range planning is in emphasis [7]. Long-range planning is generally considered to mean the development of a plan of action to accomplish a goal or set of goals over a period of several years. Table 1 illustrates the differences between strategic planning and conventional long-range plan.

Strategic planning allows an organization to become as successful as it possibly can be. It serves as a roadmap to the organization’s future. A well-developed strategic plan should contain the basic information necessary to begin the formulation of an integrated performance measurement system as shown in Table 2 [8].

The quality of a strategic plan depends on the mode used to organize the strategic planning process within the organization [6]. Some of the key elements of such a process are [6]:

- presence of strong leadership and vision amongst the organization’s management,
- an approach that presumes high levels of participation and consultation with a wide range of employees within

- the organization and with external stakeholders that are part of the strategic process,
- a specifically developed approach that uses best practice examples, but adjusted to correspond to the specific needs of the organization and the resources that it has at its disposal,
 - collection of hard evidence used to inform the process of establishing strategic goals,
 - a realistic assessment of resources and available human capacity,
 - review of a wide range of views and priorities prior to taking decisions with the aim of reaching consensus,
 - new ideas and continuity that ensure that the strategic plan, as well as the strategic planning process, is regularly analyzed and revised.

Table 1
Strategic planning vs. conventional long-range plan

Strategic planning	Conventional planning
External focus	Internal focus by the Chief Procurement Officer (CPO)
Process oriented a stream decisions by the Chief Executive Officer (CEO)	Product oriented, for example, the approved master plan
Dynamic and change oriented	Emphasizes stability
Innovation and creativity	Relies on tried and tested
Vision of the future that guides decision-making	Blueprint for the future that is to be carried out

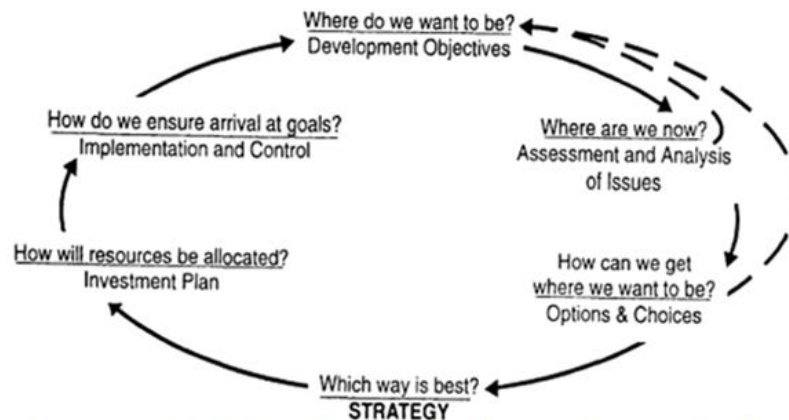
Sources: M. Meredith, R.G. Cope, O.T. Lenning, Differentiating Bona Fide Strategic Planning from Other Planning, U.S. Department of Education, Washington, DC, ERIC, ED 287 329, 1987.

Table 2
Strategic plan elements and performance measurement attributes [8]

Strategic plan elements	Performance measurement attributes
Strategic goal	Articulates the enduring mission or “end state” desired
Objective	Describes the strategic activities that are required to accomplish the goal
Strategy	Defines strategic (long-term) requirements that link to objectives. Typically contain dates, basis of measurement, and performance aspirations (targets)
Tactical plans	Identifies the short-term requirements that link to strategy. Typically contain cost, time, milestone, quality, or safety attributes as well as performance targets

Table 3
Process used to define strategic goals and programs

Steps	Actions
Setting strategic issues	- Setting strategic (priority) issues. - Consolidating a list of strategic issues.
Establishing strategic goals	- One strategic goal to be determined for each of the strategic issues. - To analyze each of the strategic goals against SMART criteria. - Development of a final strategic goals list (up to 3–5 goals max.).
Establishing strategic programs	- To establish a list of programs/activities needed to realize the goal. - To determine carriers and deadlines/dates of implementation for each of the programs/activities.
Determining priorities	- Determining prioritization criteria. - Sorting programs/activities in accordance with the criteria established. - Determining of the final programs/activities list according to priorities.



Source: A Guide to the Formulation of Water Resources Strategy, Edited by Guy Le Moigne, Ashok Subramanian, Mei Xie and Sandra Giltner, World Bank Technical Paper Number 263, 1994.

Fig. 1. The strategic planning cycle.

The strategic planning process steps are outlined in Table 3. SWOT (Strengths, Weaknesses Opportunities, Threats) is used to assess the strengths, weaknesses, opportunities, and threats that are strategically important to the organization. SWOT may be included in the strategic plan but as supporting documentation.

Fig. 1 illustrates an overall strategic planning cycle. Development objectives and key policies provide the platform from which to launch an assessment and analysis of issues. The examination of major issues and the evaluation of options may reflect back on development objectives, as illustrated by the dotted lines in Fig. 1.

3. Desalination issues emphasized in the Saudi National water plans

An early “Assessment and Strategic Plan” of the water sector was carried by Ministry of Economy and Planning in 2010 in collaboration with GTZ International Services/ Dornier Consulting. The Ministry of Water and Electricity (MOWE)¹ issued in 2014 a draft of the National Water Strategy 2014 (NWS 2014) with technical assistance provided by The World Bank [9]. The NWS 2014 has developed a guideline about water portfolio management till 2030 including all water use (agriculture, industry and municipal). MOWE works on the preparation of the strategy for some decade. The following are general directives from

the Saudi Arabia’s Five Year Development Plans² regarding the development of National Water Strategy which were proposed by MOWE.

- The Sixth National Water Plan (1415–1420, 1995–2000): Preparation of the National Water Strategy during the Sixth Development Plan to achieve optimal utilization of water and conservation of its sources.
- The Eight National Water Plan (1425–1430, 2005–2010): Completion of the preparation of the Eight National Water Plan.
- The Ninth National Water Plan (1430–1435, 2010–2015): The plan ensures the completion of National Water Strategy that involves spatial database compilation, water usages statistics, and mechanism and procedures for implementation. The Ninth Plan will also enhance implementation efficiency of water policies, focusing on the demand side of water management, along with supporting and developing water-saving technologies.
- The Tenth National Water Plan (1435–1440, 2015–2020): accelerate the approval of the National Water Strategy and implementation of its comprehensive plan.

Eventually, the National Water Strategy of 2014 was not officially approved. The following is an extract from the National Water Strategy of 2014 regarding desalination issues [9].

¹The Ministry of Water and Electricity (MOWE) is a former Saudi ministry that was responsible for supervising water and electricity in Saudi Arabia. The Ministry of Environment, Water and Agriculture (MEWA) was established by virtue of the Royal Decree number (A/133), dated 30/07/1437 AH (May 8, 2016), upon which the “Ministry of Water and Electricity (MOWE)” was abolished, and the name of the Ministry of Agriculture (MOA) was changed to the Ministry of Environment, Water and Agriculture (MEWA), and transfer the tasks and responsibilities related to the environment and water activities to it.

²Saudi Arabia used five-year development plans to report on achievements, statistics, and present the goals and objectives of the Kingdom for the proceeding five years. Saudi Arabia has pursued ten successive five-year development plans (1970–1975 to 2015–2020). In 2016, “Saudi Vision 2030” was launched, providing an ambitious blueprint to restructure the Saudi economy, lessening its dependence on oil and creating more socioeconomic opportunities. More details are included in the National Transformation Program 2020 (NTP) and the Fiscal Balance Program 2020 (FBP), both also launched in 2016.

- The trade-off between groundwater use and reliance on desalination

Desalination is seen as a viable alternative to securing water for towns and cities to the extent that nowadays more than 60% of the water supply comes from desalination plants. But as population and economic growth continue on a fast track, it would be unreasonable to assume that all the growth in municipal and industrial water demand will have to be absorbed by new investments in desalination plants.

First MOWE needs to introduce strong water demand management measures (metering, realistic pricing, reduction of distribution losses) to curve down demand before embarking in a systematic desalination plant build-up. Second, the desalination option should be considered as part of a wide range of supply options during the integrated planning process with due consideration to the optimization of technical, economical and environmental aspects.

Desalination may prove to be the best new supply option for high-valued uses of water in coastal regions where efforts to maximize efficiency are being made and where absolute supply constraints are severe. For inland supply at long distances from the desalination site it is imperative to consider the cost structure for fresh or brackish groundwater produced, treated, and supplied locally. In brief, only after an accurate assessment of the local hydrological and economical conditions has been drawn up is it possible to develop a well-considered action plan for the development of additional desalination capacities.

- Optimizing desalination as a source
- Each desalination project will be fully assessed on a case-by-case basis

Given the high cost of desalination water, it will be used as a strategic water supply alternative as appropriate. Since each desalination project is unique and depends on project-specific conditions and considerations, each project will be evaluated on a case-by-case basis, with transparency and public participation throughout the planning, design and evaluation processes. An EIA will be conducted for all desalination facilities, and mitigation plans will be put in place to minimize and mitigate unavoidable environmental impacts. Projects will have to ensure equitable access to benefits from desalination and avoid disproportionate impacts particularly to vulnerable communities. This rigorous evaluation of projects and the associated disclosure and participation aspects and EIAs will ensure optimization of benefits (and minimization of costs) to society and the environment.

- Desalinated water will be assessed within a balanced supply package

Desalination has high financial and environmental costs, and the energy cost is rising. Utilities will, therefore, consider all alternatives before opting for new desalination sources, based on studies of benefits, costs and environmental impacts for desalination compared to other water supply alternatives available to that area. Energy needs to be realistically priced in these studies. The water supply plan will provide, wherever possible, for transfer of part of groundwater saved in irrigation to municipal uses. Wherever possible, further renewable resources will

be mobilized. However, in most cases (save some areas in the Shield) renewable water resources are a minor source, unlikely to figure largely in the water supply plans.

- The Kingdom will further develop its global leadership in renewable energy-desalination

Saudi Arabia can become a leader in renewable energy (RE) desalination technologies and will therefore continue its strategic support to R&D in desalination processes, in the use of RE for desalination, and in mitigation of desalination-related environmental impacts. Saudi Arabia will develop knowledge management for desalination, disseminating monitoring results on desalination and creating a database and repository for storing and disseminating information. All desalination investment will seek to leverage new technologies for desalination and RE. The Kingdom will also benefit from its global leadership in desalination as well as strong capacity already existing at Saline Water Conversion Corporation (SWCC) by building industries around the technologies. Given the rising costs of energy, Saudi Arabia will conduct studies of the renewable energy-desalination nexus to evaluate the optimal technologies for desalination and renewable energy. Joint efforts being made by the King Abdullah City for Atomic and Renewable Energy (KACARE), King Abdulaziz City for Science and Technology (KACST) in collaboration with the IBM in Al-Khafji (to use concentrated PV for desalination) will continue.

- The Kingdom will take the lead in managing regional environmental impacts of desalination

The Kingdom will assume the leading role for developing a coordination mechanism with other countries that are also tapping into the same shared water bodies in order to maintain the health of the shared-water ecosystem. In this context, the Kingdom will build on existing initiatives at the GCC level in terms of development and adoption of a common regulatory framework to ensure environmental sustainability of shared water bodies. It is also very important to include in this effort other countries that are outside the GCC but share water bodies with the Kingdom.

- Utilities will progressively move to paying the full cost of desalination water

Desalinated water is a critical component of the Kingdom's water supply portfolio but use still has to reflect its high cost and environmental impacts. Saudi Arabia will progressively move to full cost pricing of desalination to create the incentives for efficient water sourcing, reducing fiscal outlays and promoting private sector participation in desalination investments.

The Saudi Arabia National Water Strategy 2030 was prepared by Booz Allen Hamilton. The Saudi National Water Strategy 2030 aims to work towards addressing all the key challenges, leveraging previous and on-going studies, and reform the water and wastewater sector to ensure sustainable development of the kingdom's water resources while providing affordable high-quality services [10]. The National Water Strategy 2030 is composed of a vision, strategic objectives, programs, and associated initiatives.

The sector's vision statement cites: "A sustainable water sector, safeguarding the natural resources and the environment of the Kingdom and providing cost-effective supply and high-quality services," as the central goals. This vision statement can be further detailed into five strategic objectives, as follows:

- (1) *Ensure* continuous access to adequate quantities of safe water, under normal operations and during emergency situations.
- (2) *Enhance* water demand management across all uses.
- (3) *Deliver* cost-effective and high-quality water and wastewater services, accounting for affordability.
- (4) *Safeguard* and optimize the use of water resources, while preserving the local environment for the highest benefit of the Saudi society in this generation and the future.
- (5) *Ensure* water sector competitiveness and positive contribution to the national economy through promoting effective governance, private sector participation, localization of capabilities and innovation.

The following are review of Program 2 titled "Water Resource Management" and Program 7 titled "Desalination Sector Institutional Reform" which focused on Saudi desalination.

- *Program 2: Water Resource Management.*
Initiative 10: Development of Sustainable Desalination.
Initiative to develop desalination capacity following an assessment of local hydrological and economic conditions, while improving costs, energy efficiency and environment footprint and also accounting for the expansion in renewable energy.

Key Activities:

- Develop a roadmap for clean energy desalination for the Kingdom (clean energy supply for desalination, energy efficiency system integration, research and development (R&D), outreach, action plan etc.),
- Integrate findings with master plans,
- Leverage new and efficient technologies for all new desalination investments and refurbishment of existing desalination plants,
- Undertake pilot studies in collaboration with SWCC R&D and academic institutions to assess techno-economic feasibility of desalination using renewable energy, and,
- Undertake studies to assess the environmental impact of desalination and implement necessary measures to mitigate impact on the environment.

Key performance indicators:

- Renewable energy share of desalination fuel supply mix. (%); and,
- Energy consumption (kWh/m³/100 m).
- **Implementation Risks:**
 - Renewable energy technologies remain relatively costly compared to conventional fuel,
 - Delay in obtaining financing for investing in sustainable technologies, and,
 - Shift in government policy inhibiting development of sustainable technologies.

- *Program 7: Desalination Sector Institutional Reform*
This program was developed as part of the SWCC privatization strategy. It entails the restructuring and transformation of SWCC to achieve its revised mandate. The program will be sponsored by SWCC and will include two initiatives.

Initiative 1: Commercialization and TRANSCO Setup.
Initiative 2: Preparation for Production Privatization.

Unified Water Strategy (UWS) for the Gulf Cooperation Council of Arab Member States for the Years 2015–2035 was developed in response to the directives of their Majesties and Highnesses the leaders of the Gulf Cooperation Council (GCC) at their 31st session of the Supreme Council of the Cooperation Council for the Arab Gulf States in Abu Dhabi on 6–7 December 2010. The scope of work of the unified water strategy had two main elements [11]:

- To develop a comprehensive and unified water strategy for the GCC countries for the next 20 y.
- To establish an office of strategic management in the GCC countries to implement, update the unified water strategy.

The vision and mission statements of the GCC UWS are formulated as follows:

Vision: By 2035 the GCC countries have established sustainable, efficient, equitable, and secure water resources management systems contributing to their sustainable socioeconomic development.

Mission: To align GCC states' national water strategies and master plans with a unified GCC water management strategy that foster joint initiatives and strengthen the capacities of each country in achieving a rational, integrated, efficient, and sustainable management of their water resources.

The GCC UWS is founded on five strategic themes; development and sustainability of water resources, efficient and equitable water resources utilization, enhanced municipal water supply security, effective water governance and awareness and economic efficiency and financial sustainability. Each theme contains one or more strategic objective (SO). The following is an overview of theme 1 titled "Development and Sustainability of Water Resources" and its associated Strategic Objectives (SO) as well as the proposed policies and programs [11].

Theme 1: Development and Sustainability of Water Resources

Strategic Objective-1: To Acquire Technology Development and Manufacturing of Desalination and Water Treatment Plants and Diversification of Energy Resources.

Collectively, the GCC countries have the highest concentration of desalination capacity worldwide and possess over 40% of the world's desalination capacity, with desalinated water representing the main source of their drinking water supply. This percentage is expected to increase in the future. However, the added value of desalination to the economies of the GCC countries is limited.

Hence, acquiring/owning, and localizing desalination technology in the region becomes an imperative strategic objective to ensure desalination sustainability and security to support national economy. Moreover, meeting escalating municipal water demands by the expansion of desalination has been associated with enormous financial, economic and environmental costs. In particular, the currently adopted thermal desalination technology is energy-intensive, claiming with alarming rates a sizable portion of energy resources and threatening the main source of income of the GCC countries. Therefore, implementing energy efficiency programs and diversifying energy resources in desalination, as well as the whole water sector, would enhance the sustainability of desalination and would help mitigate its associated environmental impacts.

The GCC countries have set targets for renewable energy share in their energy mix. These targets need to be implemented with priority in desalination and the whole water sector since they represent a major energy consumer in the GCC. Meanwhile, to address concerns about carbon emissions, GCC governments need to link any future expansion in desalination capacity to investments in abundantly available renewable sources of energy. In this regard, there are a number of major initiatives in the region towards solar desalination (e.g., KACST in Saudi Arabia and MASDAR in UAE). Other GCC countries should be encouraged to join these initiatives. Special attention should be paid to renewable and environmentally safe energy sources, of which the most important is solar, which can have enormous potential as the GCC countries are located within the “sun belt” of the world.

Policies and programs

SO1.1 Establishing joint GCC desalination and water treatment industry.

SO1.1.1 Joint GCC investment in establishing/owning desalination and treatment industries.

SO1.2 Establishing an advanced joint GCC R&D base in desalination and water treatment.

SO1.2.1 Create joint GCC advanced research programs in desalination and water treatment.

SO1.3 Developing professional and technical capacity in desalination and water treatment in the GCC countries.

SO1.3.1 Establish a unified GCC training programs that offers technical & vocational training in desalination and water treatment aspects as a major specialization in the GCC countries.

SO1.3.2 Set-up extensive educational specialization in desalination and water treatment at the graduate and undergraduate levels.

SO1.4 Diversifying energy sources in the water sector.

SO1.4.1 Develop plans for the use of renewable energy in the water sector in each GCC country.

SO1.5 Mitigating the impacts of desalination and water treatment practices on the environment.

SO1.5.1 Develop a comprehensive environmental legislation related to desalination and water treatment and provide enforcement and compliance mechanism.

SO1.6 Enhancing energy efficiency in desalination sector and the whole water sector.

SO1.6.1 Implement energy efficiency programs in desalination sector and the whole water sector.

The Saline Water Conversion Corporation (SWCC) is a Saudi Government Corporation responsible for the desalination of seawater producing electric power and supplying various regions in Saudi Arabia with desalinated water. SWCC was established by royal decree dated 20/08/1394 (07/09/1974) as an independent government corporation. The following is an overview of SWCC main objectives, vision mission and strategic goals [12].

SWCC main objectives

The corporation aims at consolidating the natural water resource in various regions and cities of the Kingdom where there are severe freshwater shortages, through the process of desalination.

The corporation is also habilitated to produce electric power as a by-product depending on economic and technical needs.

This is carried out in accordance with a comprehensive plan devised by the corporation and approved by the Council of Ministers.

The desalination of water, in addition to the production of electricity, represents the most important objectives of the development plans envisaged by the corporation. One of the main strategic goals for the implementation of these plans is to build a number of desalination plants, along with support facilities in regions suffering from shortages of fresh water supplies, based on the outcomes of technical feasibility studies.

SWCC vision

Leadership and excellence in sea water desalination and power production.

To excel and be the pioneer in the seawater desalination industry and electricity production.

SWCC mission

To meet the needs of our customers by providing them with desalinated seawater with effectiveness and credibility, at the lowest cost possible and with the highest economic returns, motivating and investing effectively in human resources, developing the desalination industry, contributing to social and economic development while complying with safety and environmental standards.

SWCC strategic goals

1. *Customer Service*: satisfy the needs of our clients by supplying them with desalinated seawater and

electricity and deliver reliable services with the highest quality.

2. *Financial sustainability*: achieve the highest economic return by increasing revenues and reducing cost.
3. *Operational effectiveness*: ensure quality and efficiency in terms of production and operations.
4. *Human resources*: develop, motivate, and build national competencies within a work environment characterized by fairness, teamwork, responsibility and loyalty.
5. *Economic development*: contribute effectively in developing and indigenizing know how in the field of desalination.
6. *Safety and security*: comply with the best practices of safety and security.
7. *Environmental sustainability*: comply with environmental rules and regulations.

5. Development of desalination KPIs

Almasri and Almurabti [13] recommended the following key performance indicators to assess the performance of the desalination plants:

- Availability factor
- Capacity factor (CF)
- Recovery ratio
- Reliability
- Thermal efficiency
- Product quality
- Unit product cost

They mentioned that objective of the assessment work is to measure how efficient and economic a plant is in meeting its objective in producing the design quantity and quality of water [13].

The performance of a given desalination plant is a measure of its efficiency for producing water. It is a measure of how efficient and economical the plant is in meeting its objective in producing the design quantity and quality of water by using specific indicators. However, there are no standard indicators for evaluating desalination plants performance.

The Saline Water Conversion Corporation (SWCC) performance was reviewed on Electricity and Cogeneration Regulatory Authority (ECRA) report titled “Regulating, Evaluating and Monitoring the Overall Performance of SWCC – Seawater Desalination Industry Review and Baseline of SWCC Performance Report”, July 2015 [14]. SWCC is recognized for its strong technical capabilities in desalination given the scale and breadth of its operations, experience of its staff, and track record in meeting supply targets.

Within ECRA report the technical evaluation of SWCC plants was conducted by Black & Veatch. The evaluation is based on an on-site assessment of desalination plants in four locations – Jeddah, Shoaibah, Jubail and Khobar – and a review of gathered data. Table 4 lists the adopted desalination key performance indicators (KPIs).

Indeed, these indicators and criteria offer practical measures for the evaluation of the efficient operation of desalination plants.

Vision 2030 in Saudi Arabia and the National Transformation Program (NTP) call for the following key objectives for the water sector which associated with some initiatives like the ones listed [15]:

Key objectives:

- Promoting sustainable water supply sources and improving service coverage.
- Reducing excessive water consumption.

Table 4
Desalination KPIs overview

Criteria	Overview
Plant life	Commercial operation date and condition indicator.
Product quality	Quality parameters including turbidity, pH, hardness, total dissolved solids and chloride.
Plant availability	Percentage of time at which the plant is available for operation.
Production capacity	Plant’s ability in meeting annual demand.
Gain output ratio (MSF)	Energy efficiency indicator.
Loss time injury frequency rate (safety)	Rate of occurrence of workplace incidents that result in lost time.
PM-CM ratio	Preventive Maintenance (PM) hours/Corrective Maintenance (CM) hours.
Non-fuel O&M costs	Costs/m ³ (manpower, chemicals, maintenance, spare parts etc.).
Environmental Legislation	Environmental preparedness, indicator.

Table 5
National Transformation Program (NTP) – Vision 2020 initiatives

Water resources	Ensure sustained water resources to all Saudi Arabia residents and visitors.
Increase SWCC Local Content	Elevate Saudi’s capabilities and entrepreneurship in local manufacturing
SWCC privatization	Implement privatization strategy of swcc and enhance the operating model.
Enhance SWCC performance effectiveness	Ensure water safety and availability through enhancement of SWCC water production and cost reduction.

- Achieving customer satisfaction by providing high quality service and reducing waste.
- Reduce the sector dependence on state funding by taking steps toward privatization.
- Improving financial and operational efficiency.
- Rapid increase in population and unsustainable growth in water demand.
- High costs of water coupled with low tariffs making the sector unsustainable.
- Limited private sector participation in the kingdom’s water sector.

Initiative examples:

- Increasing the capacity of strategic water storage.
- Increase the proportion of desalinated water produced by private operators.
- Reduce the waste of the water network.
- Expand the role of the water regulator.
- Attracting private sector participation across the water sector.
- Increase digital content to improve customer services.
- Reduce water service time.

These objectives face following main challenges facing water sector:

- Limited natural water resources.
- Elevated per-capita consumption.

Table 6
Key initiatives of SWCC’s 2015 Transformation Program

Transformation pillars	Key initiatives
Strengthen our core business	Operational excellence Capital effectiveness
Transform our people engagement model	Human capital distinction Culture and values
Explore new and innovative frontiers	Value from intellectual property New business development
New operating model	Unbundling Integrated planning and control

Table 7
Operational excellence initiatives

Initiatives	Workstream objectives
Process and employee safety	Diagnose existing process and employee safety core practices maturity both at corporate level and within each of the four sites within scope, by focusing on: - Adopt a risk-based approach focusing on key risks areas; in particular, selecting sample areas as well as selected critical elements of the SMS based on experience in similar facilities. - Through a targeted review of core safety risks at both corporate and site level, help leadership team appreciate key risks areas and priorities to define a roadmap to develop mitigation plans and reduce overall operational risk.
Asset efficiency	Diagnose and define realistic asset efficiency target by focusing on water pumps and transmission systems, steam boilers, steam turbine and MSF, RO and MED desalination process optimization with the objective to: - Reduce the operational expenditure induced by those assets by 20%, covering such as energy and power consumption, operational and maintenance costs, chemical costs, fuel cost. - Identify opportunities to improve capacity factor of desalination plant up to 93% and capacity factor of power generation up to 90%, and plant availability up to 97% and reduce the energy consumption by 10%.
Maintenance and reliability	Identify opportunities to optimize the overall expenditures related to fix and variable maintenance activities to improve asset availability up to 97% from reducing core assets downtime, by focusing on the following: - Maintenance and reliability organization structure, staffing and supervisory skillsets, work management process (planning, scheduling, work order management), material and spares management, reliability strategies, criticality ranking, preventive maintenance, task management, lubrication, problem elimination, material management, warehouse and inventory, kitting, information management (Computerized Maintenance Management System CMMS, equipment data, parts data, technical documentation).
CAPEX and contractor management	Diagnose existing capital efficiency to corporate level and Yanbu Sample and contractor management core practices and define realistic improvement efficiency target, by focusing on the following core dimensions: - Capital project/investment program effectiveness during business planning, front-end loading, design and construction, contractor management, namely contract performance, interface management, consumption patterns analysis and contractor performance evaluation. - Identify opportunities to optimize overall contractor spend, optimize capital expenditure for minor CAPEX investments, and optimize long term balance between capital expenditure and operational expenditure.
Culture and performance management	- Evaluate the overall corporate culture on each of the different sites and within core corporate functions by focusing on selected leadership team members thorough profiling and coaching, leveraging established practices around felt leadership models.

- Substantial investments required in the near future for new capacity to offset
- Planned decommissioning of existing desalination plants.

Table 5 lists major initiatives which will be executed through the National Transformation Program (NTP) of Water Sector in Saudi Arabia.

So to get in-line with these directions, SWCC is considering new corporate strategy which is under development and will focus on eight key initiatives along four transformation pillar. Table 6 display the recent SWCC corporate strategy [16].

SWCC has embarked on the following program to operational excellence initiatives which listed on Table 7 [16]:

- Full environmental compliances.
- Improve process safety and reliability.
- Reduce fuel and energy consumption.
- Improve desalination plants efficiency.
- Maximize the production.
- Reduce the cost SR/m³.

6. Conclusions

Key performance indicator (KPI) is a metric which is one of the most important indicators of the current performance level of an individual, department and/or an organization in achieving goals. Key performance indicators (KPIs) are defined as a representation of a set of measures focusing on those aspects of organizational performance that are the most critical for the current and future success of the organization. KPIs are part of a strategic management system. They provide information into whether strategies are working, and programs, objectives and goals are accomplished. Often the strategic plan identifies goals, strategies, objectives and key performance indicators.

The principles KPI were reviewed in view of the strategic objectives and goals. The importance of the development of strategic plan was empathized. General overview of desalination issues which were indicated in various Saudi national water plans were highlighted. Eventually desalination KPIs were listed which include and not limited to: availability factor, capacity factor, recovery ratio, reliability, thermal efficiency, product quality and unit product cost.

In the development of KPIs for desalination processes, benchmarks and targets should be specified. Targets must be

specific and time-bound. A target within the KPI identifies the achievement in relation to the final goal.

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