جامعة الخليج العربي
Arabian Gulf University

Quantifying & Benchmarking Electricity Consumption in the Municipal Water Sector

Case study: Kingdom of Bahrain

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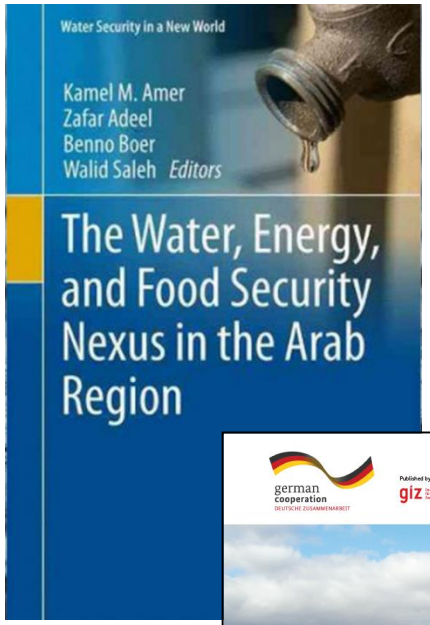
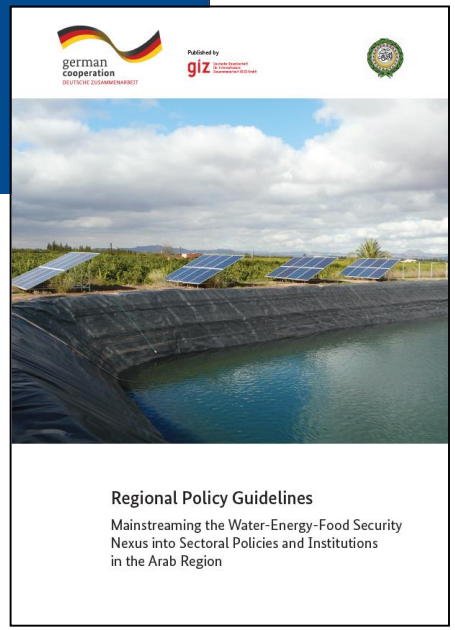
AGU Research Focus

- Quantifying the W-E(-F) Nexus
- Identifying critical interdependencies and risks
- Modeling the W-E Nexus dynamics to support decision making and policy formulation
- Analyzing W-E nexus governance & institutional structures

Examples





Available at: https://www.water-energy-food.org/regions/middle-east-and-north-africa-mena/resources/8/

Examples

Scientific Research Publishing

Computational Water, Energy, and Environmental Engineering, 2018, 7, 1-26
http://www.scirp.org/journal/cweee
ISSN Online: 2168-1570
ISSN Print: 2168-1562

Assessment of the Water-Energy Nexus in the Municipal Water Sector in Eastern Province, Saudi Arabia

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https://doi.org/10.4236/cweee.2018.71001

Abstract

When it comes to water and energy, it is hard to obtain one without the other. Water is required to produce energy and energy is necessary in water production and management. As demands for water are escalating due to rapid population growth and urbanization, understanding and quantification of the interdependency between water and energy, along with analyzing nexus interactions, trade-offs and risks are a pre-requisite for effective and integrated plan-

Scientific Research Publishing

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Energy Consumption in the Municipal Water Supply Sector in the Kingdom of Bahrain

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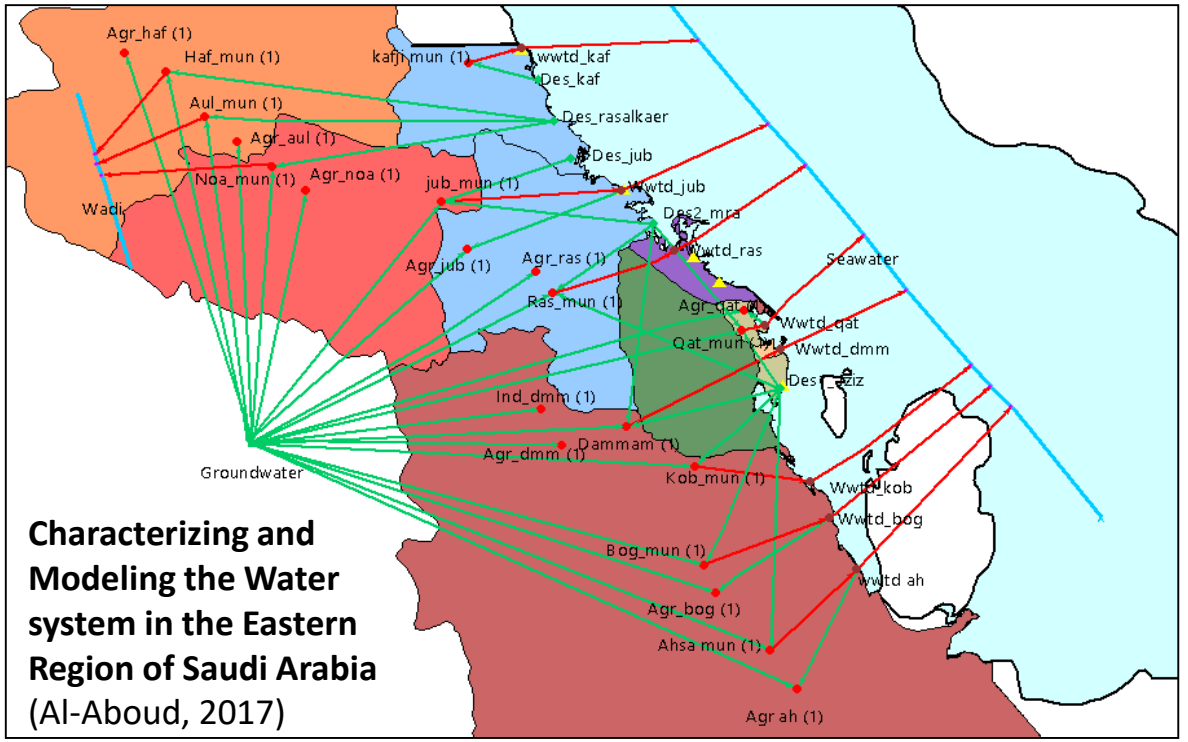
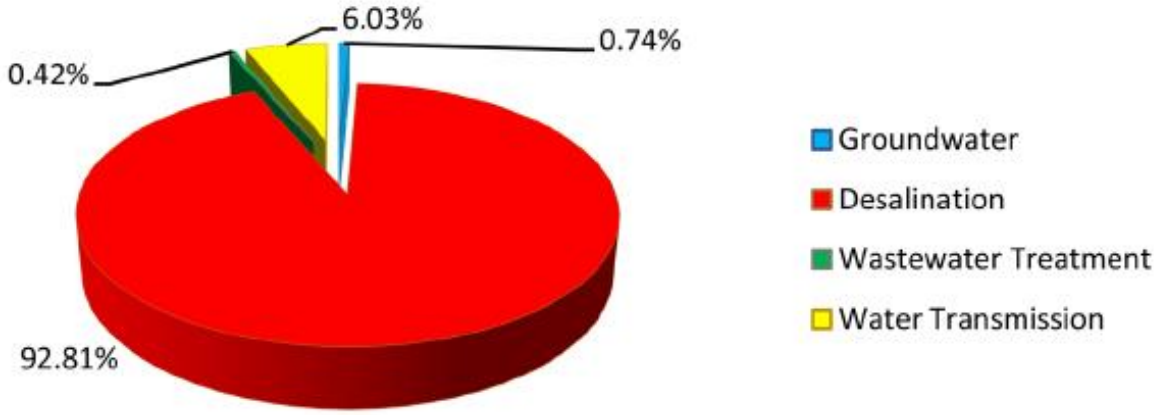


Characterizing and Modeling the Water system in the Eastern Region of Saudi Arabia (Al-Aboud, 2017)

Water Value Chain Electric Energy Consumption in 2013 in Eastern Province, KSA



Electric Energy Consumption of the Water supply in 2013 in in Eastern Province, KSA

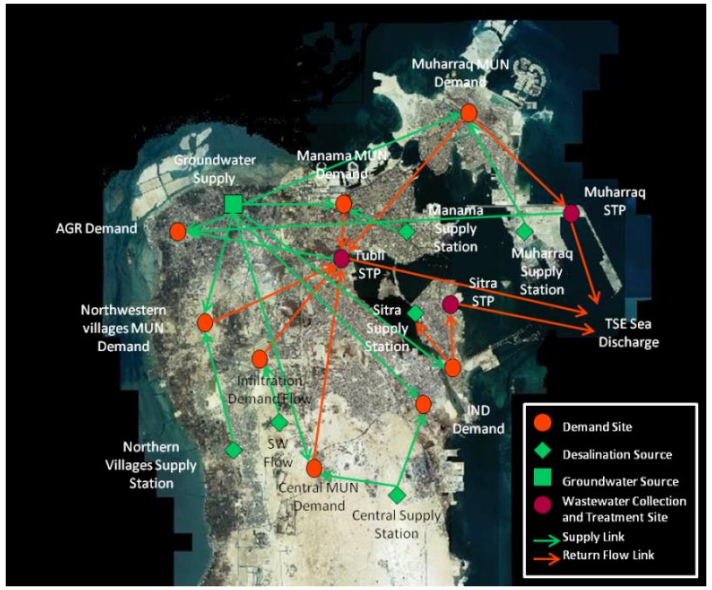
Process	Gigawatt (%)	KWH/m³
Desalination operation	25,977	41.5-39.5-7.4 (MSF, MED, RO)
Desalination transmission to Eastern Province Cities	281	0.87
Desalinated water transmission to Riyadh	1407	4.2
Total transmission (to Eastern Province Cities and Riyadh)	1688	5
Total desalinated water production and transmission	27,665	

Water Intensity for Power Plants in 2013 in in Eastern Province, KSA

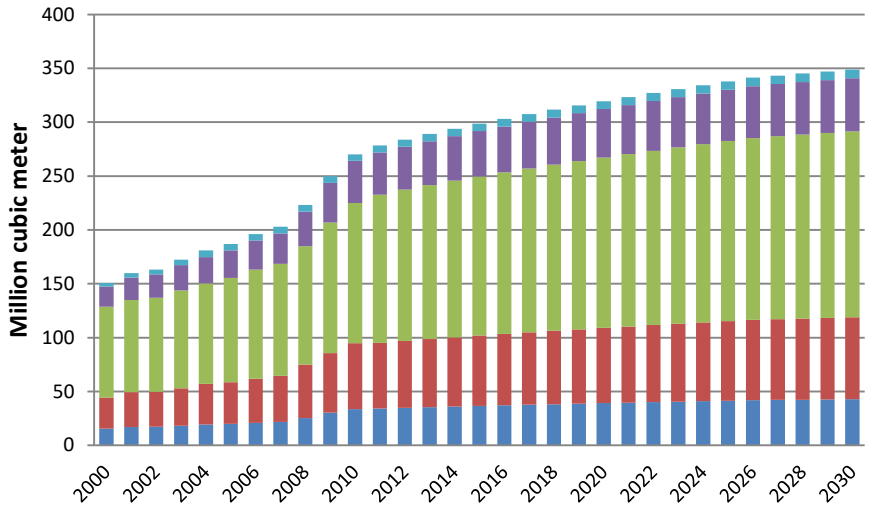
Plant	Design capacity	Water usage (m³/y) 2013	Production MWH	m³/MWH	Average m³/MWH
Shedgum power plant	1429.5	1,508,040*	12,522,420	0.120	
Faras power plant	1058.7	1,160,030	9,274,212	0.125	
Berri power plant	278.1	295,693.2	2,436,156	0.121	0.125
'Uthmania power plant	412.2	502,680	3,610,872	0.139	
Juaymah power plant	169.5	179,528.4	1,484,820	0.120	

Al-Mutrafi, et al. 2018

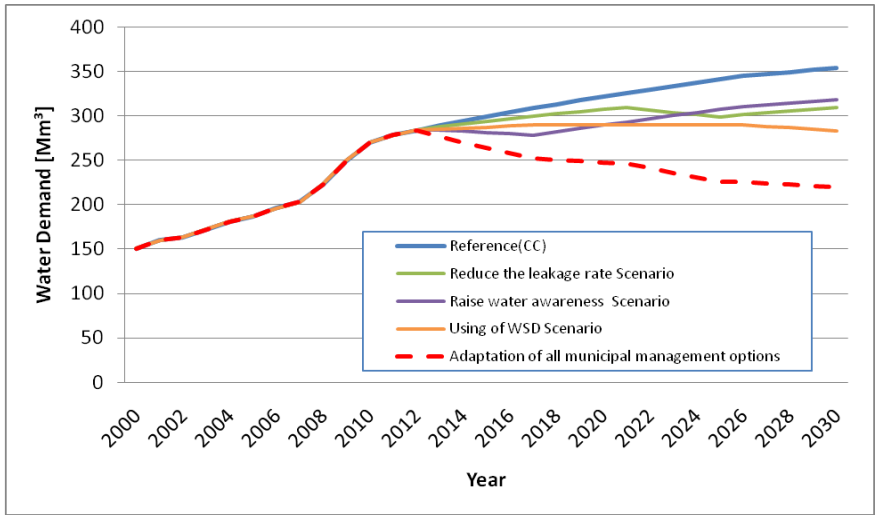
Effects of Demand Management Interventions on the Energy Consumption and GHGs Emissions Kingdom of Bahrain



Bahrain total municipal water demand



Demand management options



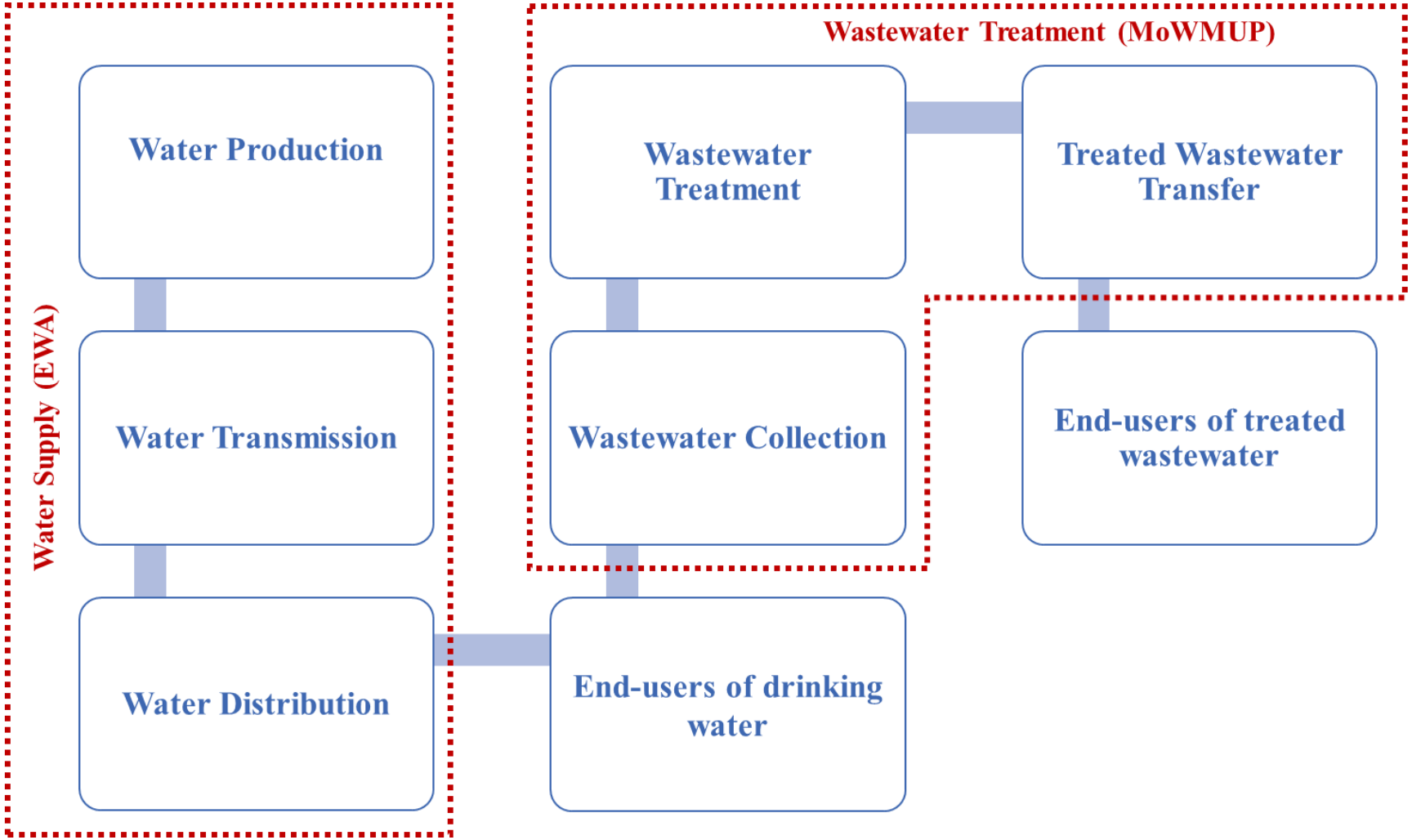
Management Interventions	Total Cum Reduction (Mm^3)	Financial Saving (MUS$)	Natural Gas (Mm^3)	CO_2 Emission (Mkg)
Leakage reduction in municipal network	432	**831**	**363**	**5,672**
Consumers water awareness raising	527	**1,013**	**443**	**6,920**
Use of water waving devices	674	**1,296**	**566**	**8,850**
All measures combined	1,500	**2,885**	**1,260**	**19,695**

Al-Zubari, et al. 2018

Study Objectives

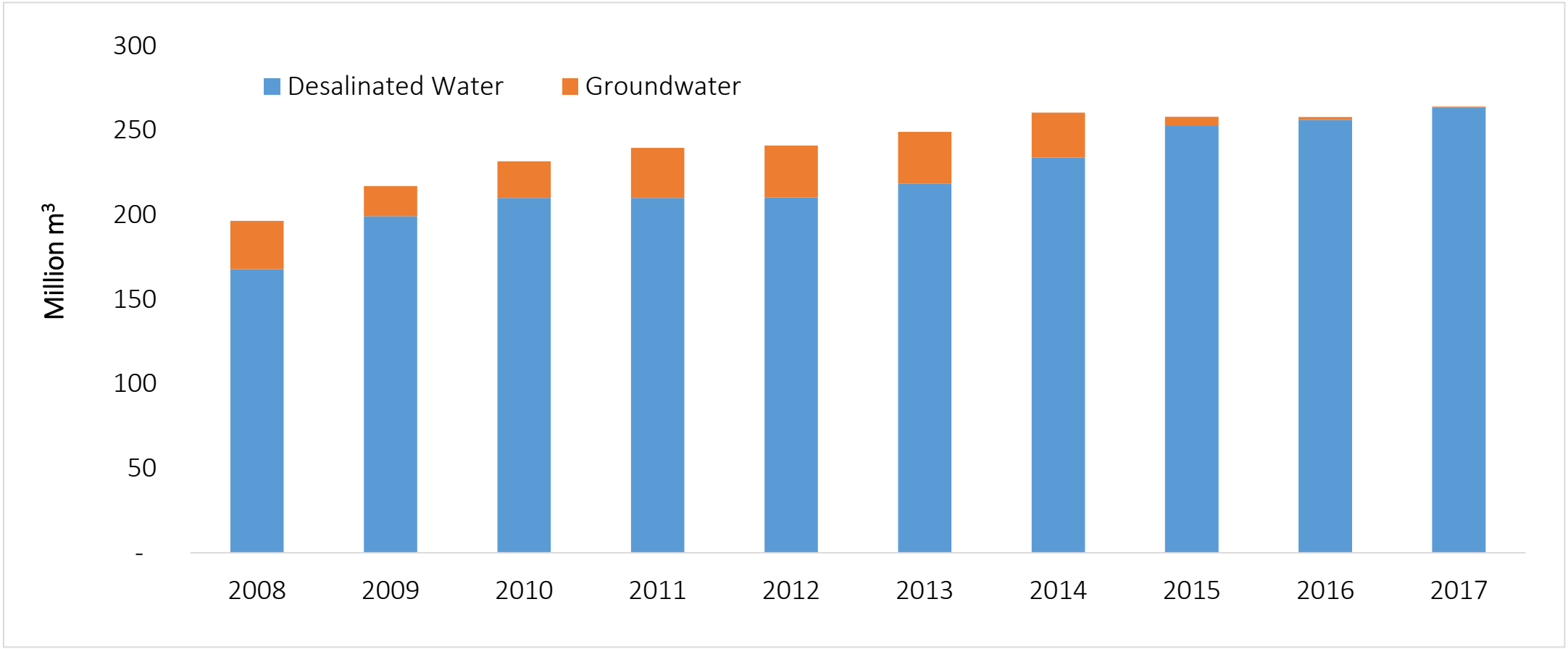
- Identifying electricity use in the municipal water cycle in Bahrain (i.e., water supply and wastewater treatment and reuse)
- Calculating relevant energy performance indicators
- Benchmarking energy performance indicators with existing international best practices

The Municipal Water Sector in Bahrain



The Municipal Water Sector in Bahrain

Water Production in Bahrain, 2008–2017 (EWA, 2017; IeGA, 2016)



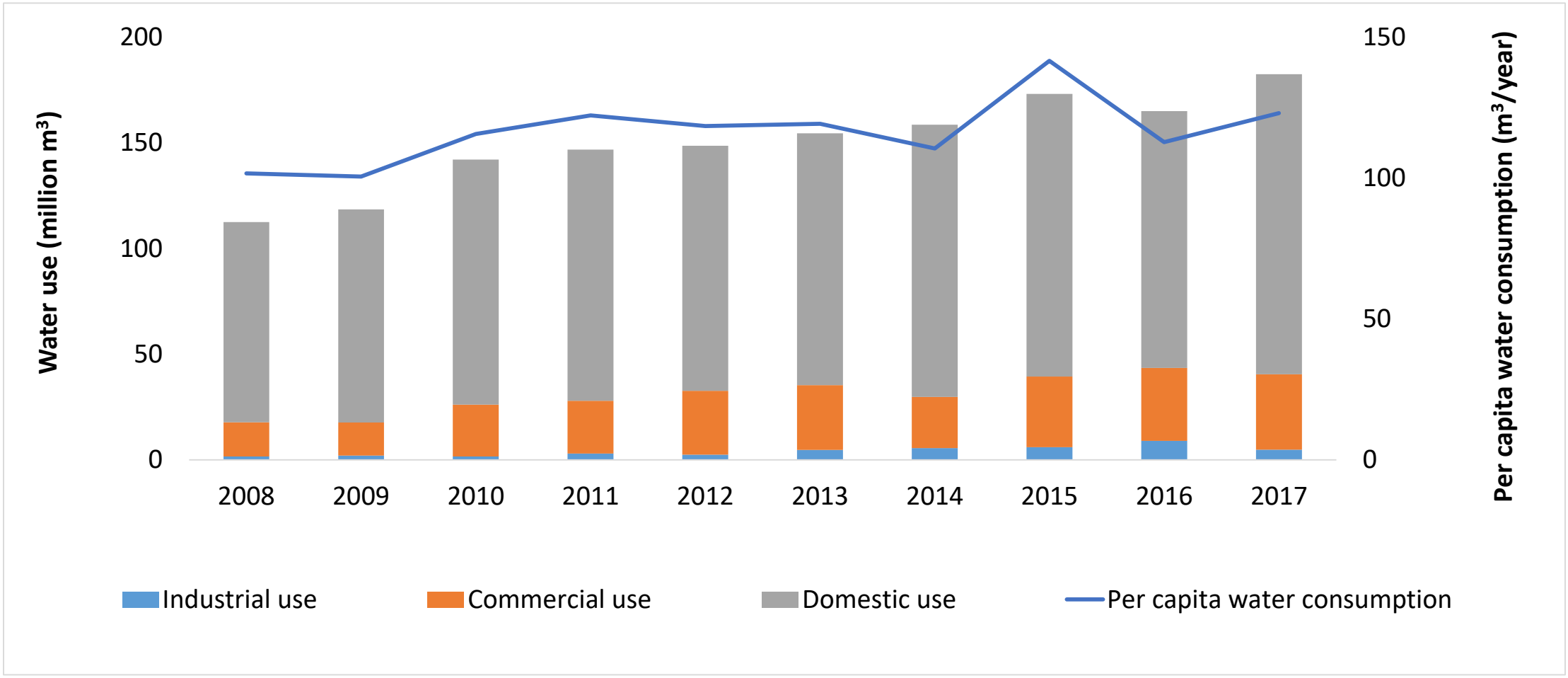
The Municipal Water Sector in Bahrain

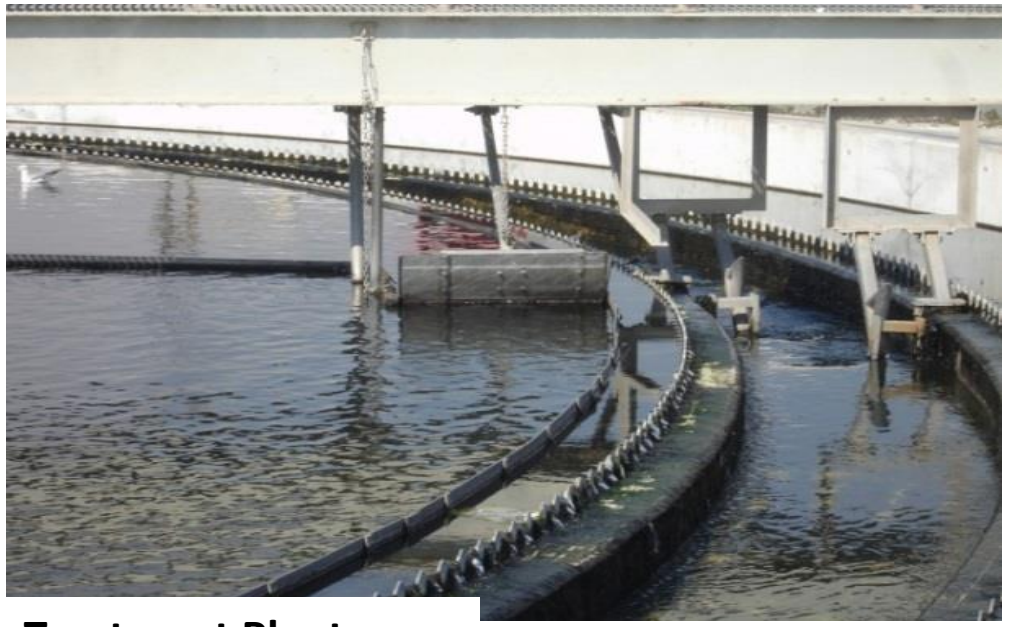
Water desalination plants in Bahrain

This slide is taken from a presentation delivered by Eng. Maryam Juma

The Municipal Water Sector in Bahrain

Water use by sector in Bahrain for the period 2008–2017 (EWA, 2017; IeGA, 2016)





Tubli Wastewater Treatment Plant

These photos are provided by Eng. Rehab Abdulmahdi

Sitra

Askar

Muharraq

These photos are provided by Eng. Rehab Abdulmahdi

Methodology

- Two approaches to energy data collection
  - Bottom-up approach
  - Top-down approach
- What energy data should be collected?
  - Electricity consumption
  - Total energy consumption
- A hybrid approach was adopted in this study where both bottom-up and top-down data collection approaches were followed
- Only electricity consumption was made

Methodology

- The total electricity consumption was calculated as follows:

$$E_i = \Sigma E_{m,i}$$

where E is the total electricity consumption for month m of year i.

- When a bottom-up data collection was applied, these equations were followed:

$$P = V * C * \sqrt{\text{Number of phases}} \times PF$$

where P is the electrical power in kW, V is the voltage in volts, C is the current in amperes, and PF is the power factor

- Electricity consumption is calculated using the equation

$$E = P * T$$

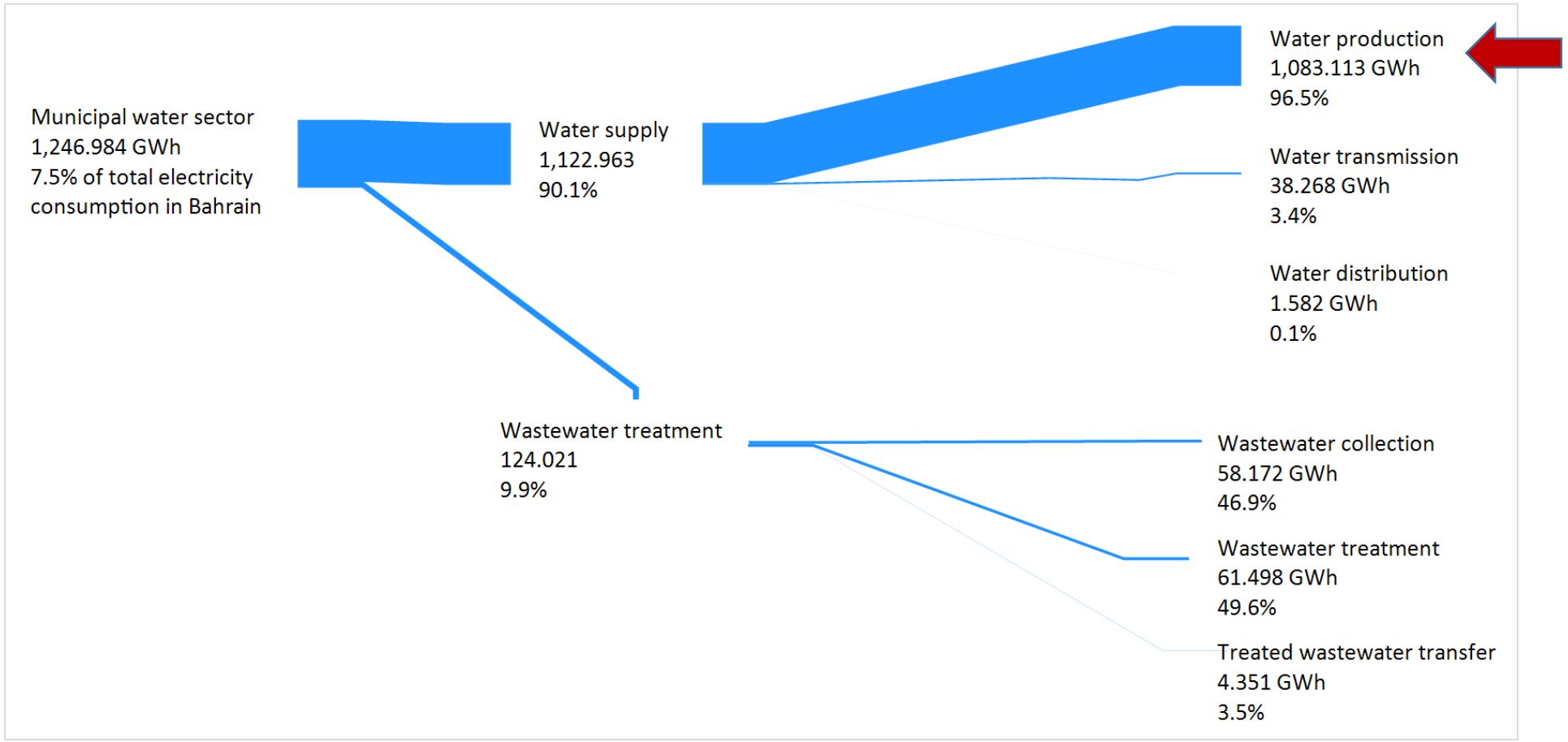
where E is the electricity consumption in kWh, P is the electrical power in kW and T is the time or working hours in h

- The specific electrical energy use indicator was calculated using the equation:

$$\text{Specific electrical energy use for a stage or a plant } (kWh/m^3) = \frac{\text{Amount of electricity consumed in a given period of time}}{\text{Amount of water produced or wastewater treated in the same period}}$$

Results

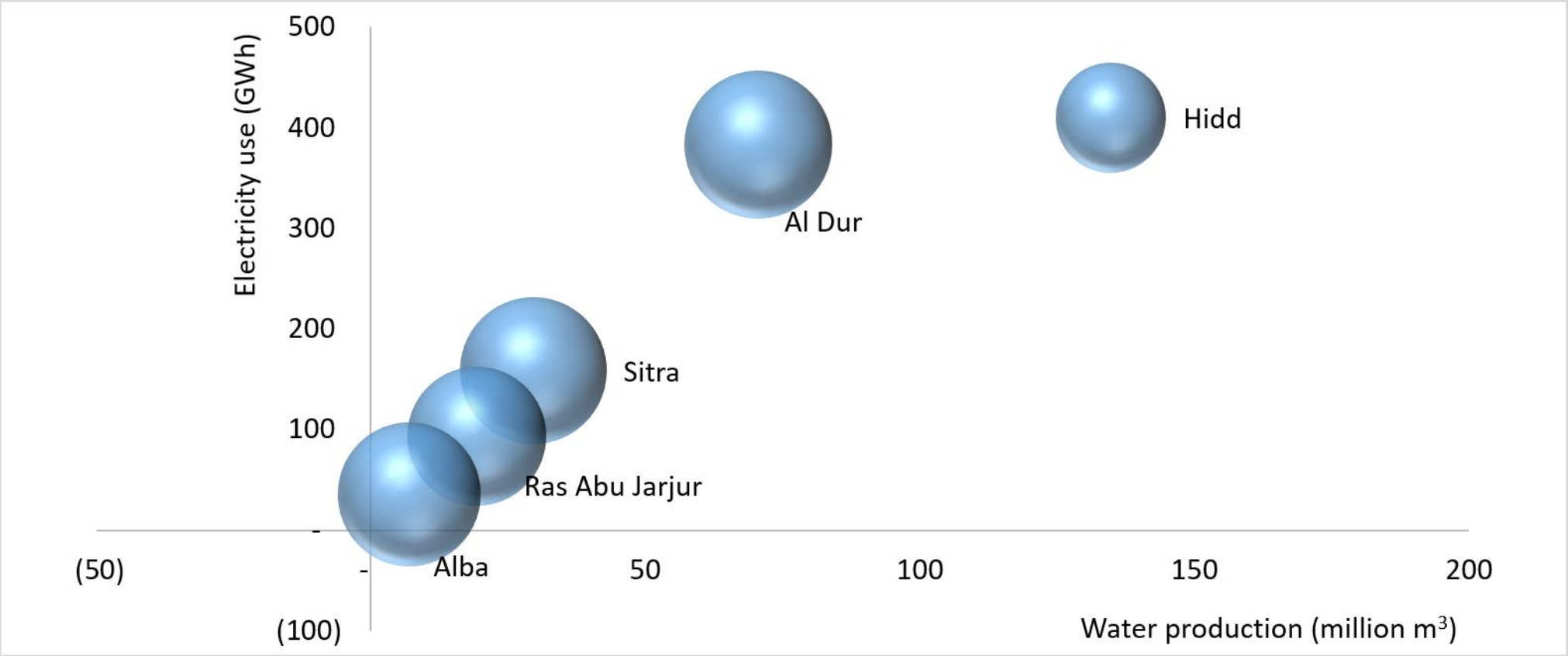
1. Identifying the electricity use in the municipal water system in Bahrain



A sankey diagram of the water-related electricity consumption in 2017 in Bahrain

Results

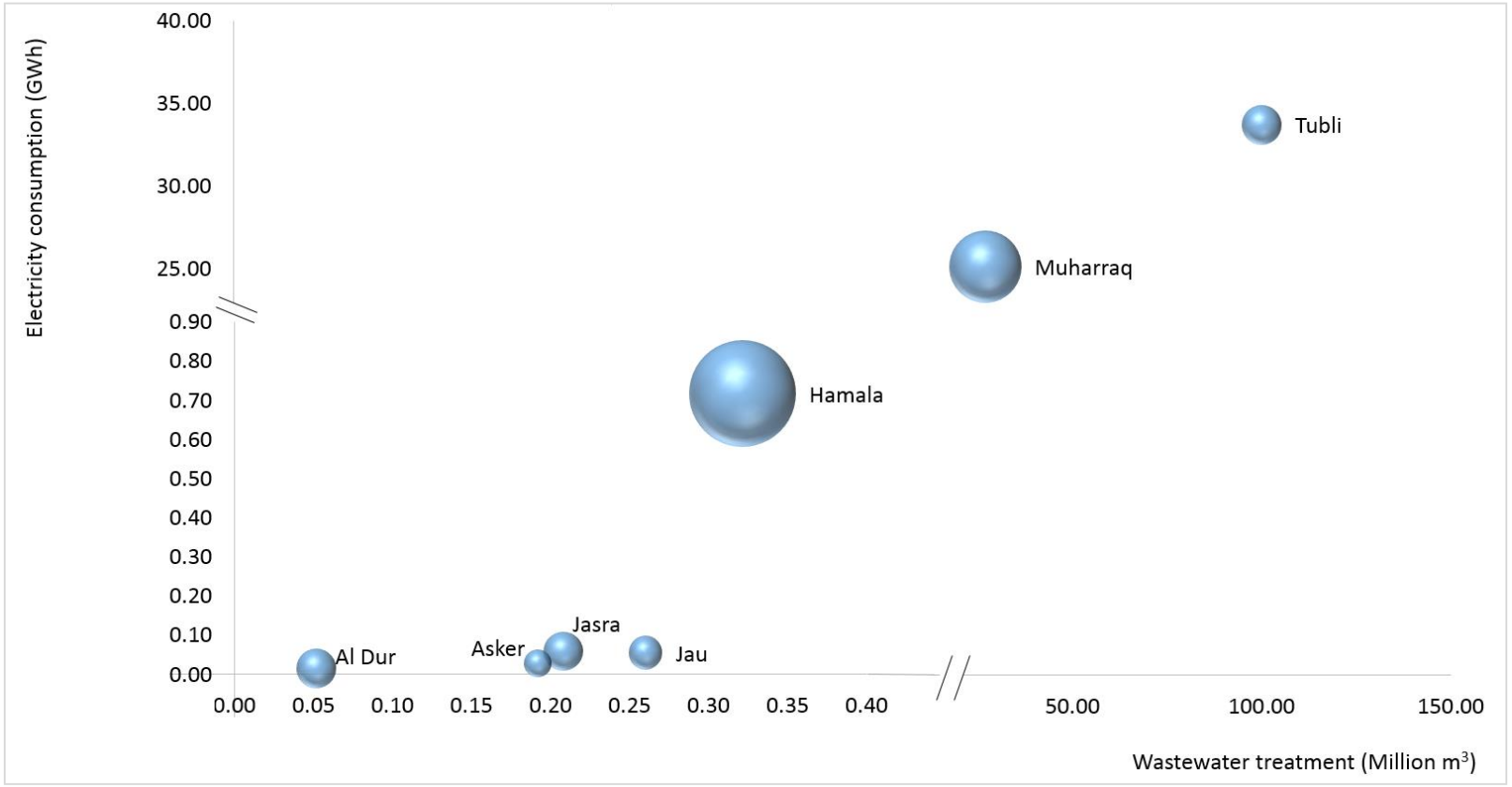
2. Calculating relevant key performance indicators – Desalination plants



Water production vs. electricity consumption and specific electrical energy use (illustrated in the bubble size in kwh/m^3) in desalination plants in Bahrain in 2016

Results

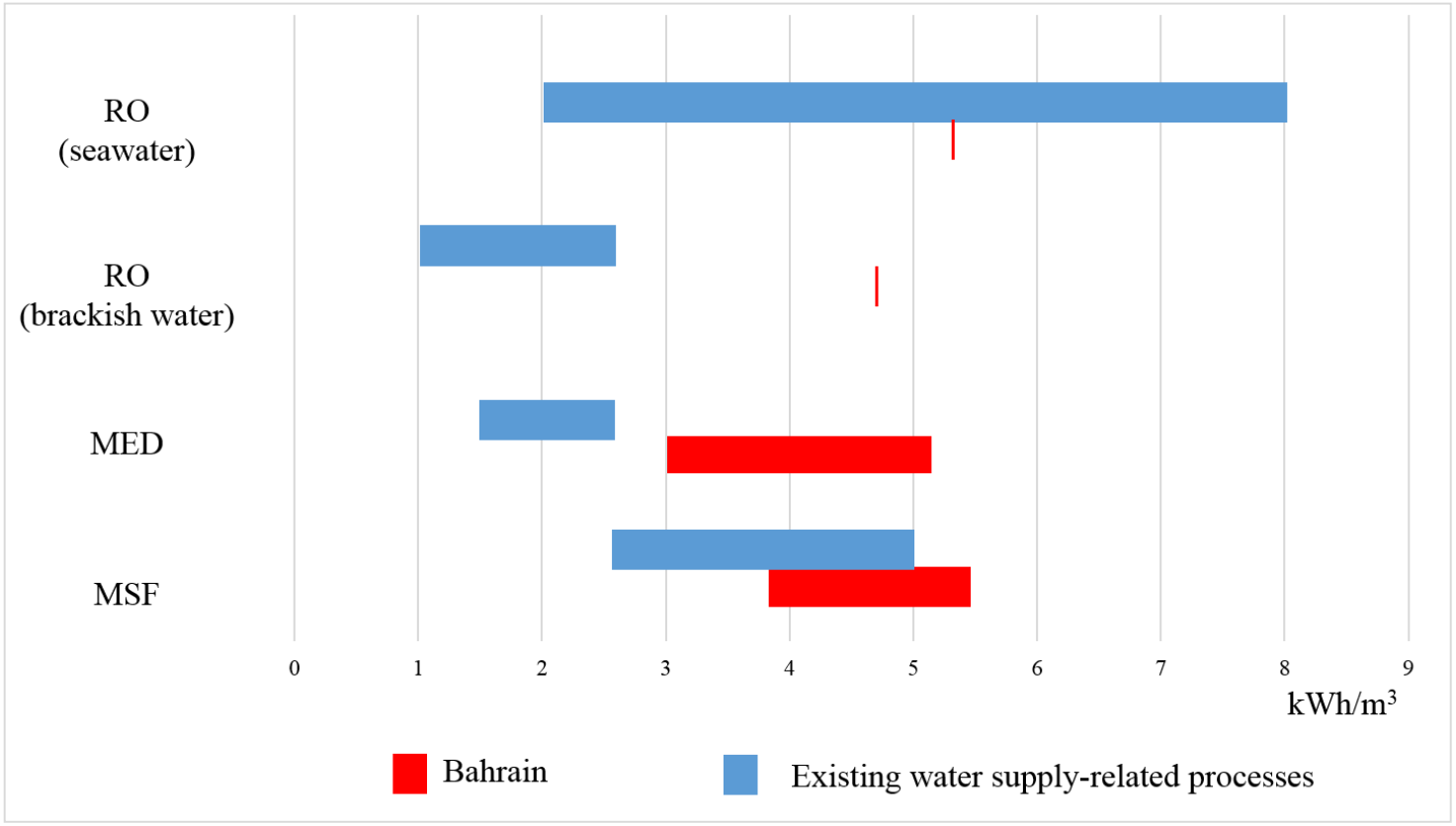
2. Calculating relevant key performance indicators – Desalination plants



Wastewater treatment vs. electricity consumption and specific electrical energy use (illustrated in the bubble size) in wastewater treatment plants in Bahrain in 2017

Results

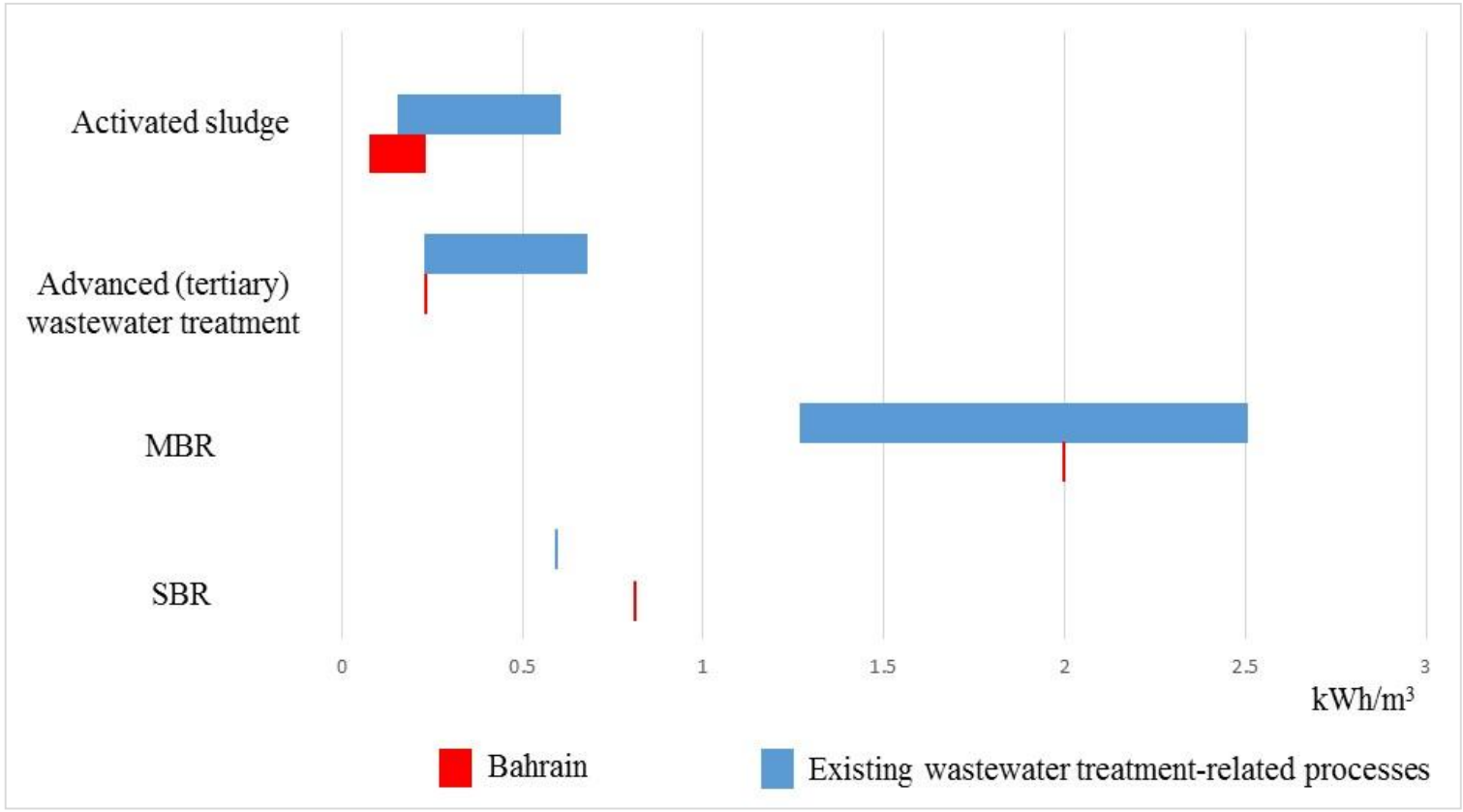
3. Benchmarking and comparing the findings with that from existing practices in the world



A comparison of specific electrical energy use in desalination plants in Bahrain with existing practices in other countries

Results

3. Benchmarking and comparing the findings with that from existing practices in the world



A comparison of specific electrical energy use in wastewater treatment plants in Bahrain with existing practices in other countries

Recommendations

- Imperative to consider the lifecycle energy assessment in informing technology selection and choices in water desalination & wastewater treatment
- Energy management to be part of the water management process
- Energy management process in the municipal water sector requires
  - Provision of energy data, development of energy management programmes, calculation and monitoring of energy performance indicators, and preparation of best practice handbooks
- Important message needs to be conveyed to the decision/policy makers and also the public at large: ‘saving water saves energy’