دائـــرة الـــطـــاقـــة
DEPARTMENT OF ENERGY

2019
ANNUAL TECHNICAL REPORT

For Water, Wastewater and Electricity Sector
in the Emirate of Abu Dhabi

Contents

1. Introduction

As Abu Dhabi Emirate continues to grow and plan for the next phase of development, the newly established Department of Energy (DoE), under Law No. (11) of 2018, is working closely with its sector partners to ensure a world-class utility sector that supports the future needs of the Emirate and meets the demands of customers.

As the sector regulator, the Department plays a critical role in establishing and monitoring the technical performance of the sector and enabling the sector to drive improvements in areas such as employee, public health, safety and environment.

This report provides an overview of the energy sector's performance in 2018 based on 2019 regulatory submissions and sheds lights on the achievements accomplished within the Emirate's water, wastewater and electricity.

This is the 2019 Technical Report by the Department of Energy (DoE).

2. Glossary

AADC	Al Ain Distribution Company
AARS	Al Ain Reception Pumping Station
ADDC	Abu Dhabi Distribution Company
ADNOC	Abu Dhabi National Oil Company
ADSSC	Abu Dhabi Sewerage and Services Company
AMPC	Al Mirfa Power Company
APC	Arabian Power Company
BOD5 (ATU)	The biochemical oxygen demand of wastewater during decomposition occurring over a 5 - day period.
CFU/100ml	Colony Forming Unit per 100 millilitre
CS	Carbon Steel
CSP	Concentrated solar power
DC	District Cooling
DEL	Dolphin Energy Limited
DI	Ductile Iron
DISCOs	Distribution Companies
DMA	District Metered Area
DMP	Distribution Metering Point
DN	Nominal Diameter
DW	Drinking Water
DWSP	Drinking Water Safety Plan
EAD	Environment Agency of Abu Dhabi
EB	Al Etihad Biwater Wastewater Company
ECPC-A2	Emirates CMS Power Company
EMAL	Emirates Aluminum
ESWPC	Emirates SembCorp Water and Power Company
EVSE	Electric Vehicle Supply Equipment
EWEC	Emirates Water and Electricity Company
FAPCO	Fujairah Asia Power Company
FEWA	Federal Electricity and Water Authority
GOR	Gained Output Ratio
GRP	Glass-fiber Reinforced Plastic
GTTPC-A1	Gulf Total Tractebel Power Company
HDPE	High-Density Polyethylene
ICAD	Industrial City of Abu Dhabi
ISTPs	Independent Sewage Treatment Plants
IWA	International Water Association
IWPP	Independent Water and Power Producers
km	Kilometer
KPI	Key Performance Indicator
l/s	Liter per second
Lphd	Litre per Household per Day
LSI	Litre per Saturation Index
LARS	Liwa Aquifer Recharge Storage

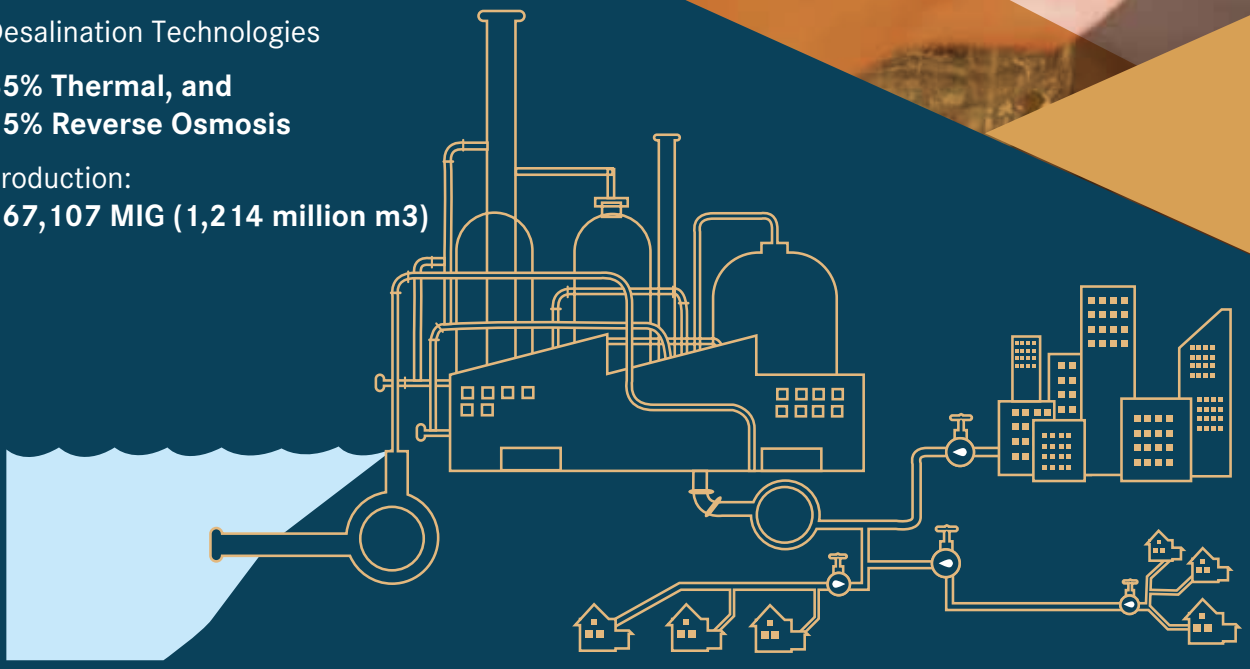
m	Metre
m3/day	Cubic Metres per Day
MED	Multiple Effect Distillation
mg/l	Milligrams per Litre
MIG	Million Imperial Gallons
MIGD	Million Imperial Gallons per Day
MIPCO	Mirfa International Power Company
Ml/day	Mega Litre per Day
MSF	Multi-Stage Flash Distillation
MWh	Mega Watt hour
NE	Northern Emirates
NRW	Non-Revenue Water
O&M	Operation and Maintenance
OPEX	Operational Expenditure
PCR	Price Control Returns
PCV	Prescribed Concentration or Value
PDSRS	Production Data Submission and Reporting System
PPB	Parts per Billion
PPM	Parts per Million
PWPA	Power and Water Purchase Agreement
REUW	Residential End-Use Water
RIA	Regulatory Impact Assessment
RPC-S2	Ruwais Power Company
RPM	Regulatory performance Measure
RW	Recycled Water
SCIPCO-S1	Shuweihat CMS International Power Company
SEWA	Sharjah Electricity and Water Authority
SF	Sampling Frequency
SFM	Sampling Frequency Measure
SMPs	Sector Measuring Points
STEP	Strategic Tunnel Enhancement Programme
SWRO/RO	Seawater Reverse Osmosis
TA	Technical Assessor
Tadweer	The Centre of Waste Management - Abu Dhabi
TAPCO-B	Plant Taweelah Asia Power Company
TDIC	Tourism Development and Investment Company
TDS	Total Dissolved Solids
TRANSCO	Transmission and Dispatch Company
TSS	Total Suspended Solids
UFW	Unaccounted For Water
VB	Veolia Besix Waste Water Company
WHO	World Health Organization
WQR	Water Quality Regulations
WQRRS	Water Quality Regulations Reporting System
WTC	Water Transmission Code

Production:
No. of IWPPs: **9**

Desalination Technologies

85% Thermal, and
15% Reverse Osmosis

Production:
267,107 MIG (1,214 million m3)



Transmission:
Network length : 3,601 Km
Pumping Station: 52 with pumping capacity 3,544 MIGD (15.71 million m3/day)
Reservoirs: 126 with total capacity 664 MIG (3.02 milliom m3)

Distribution:
No. of Customers : 397,935
ADDC: **9,079 Km, 35 pumping stations**
AADC: **4,872 Km, 8 pumping stations**

3. Water

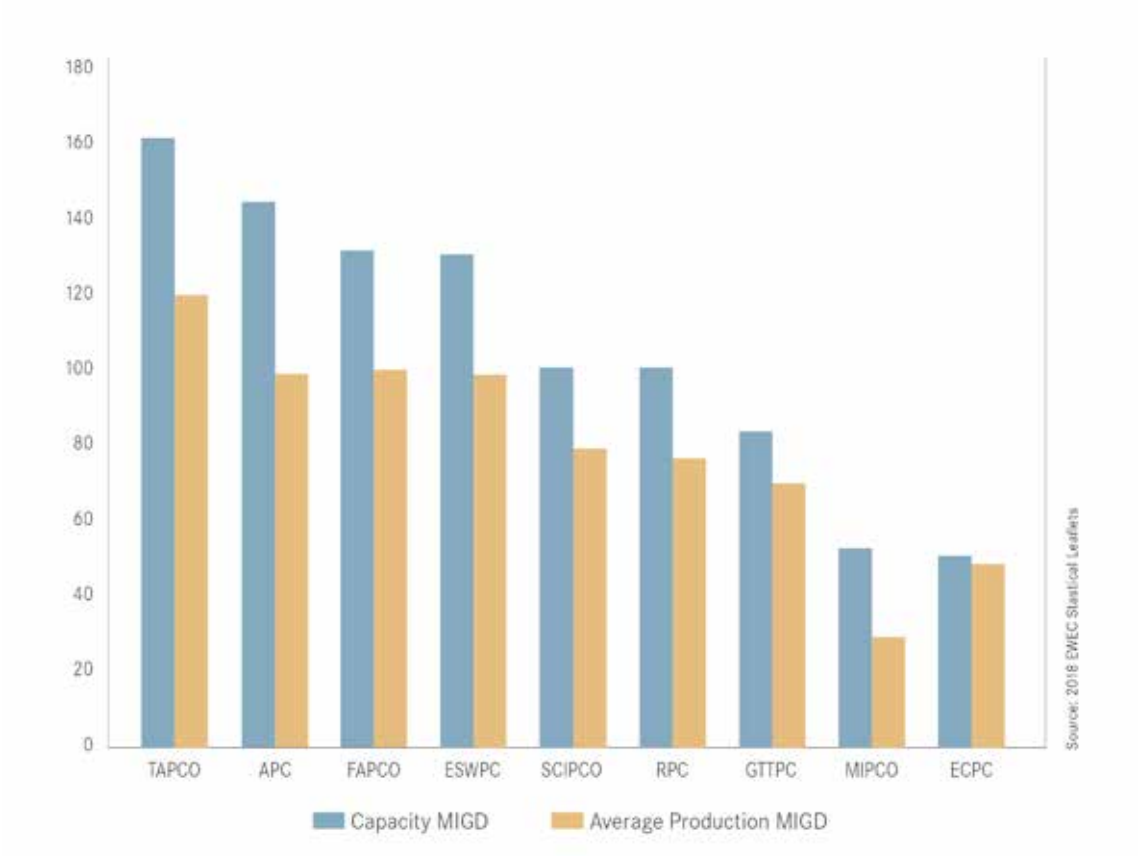
Production

Global Water Capacity and Production

In 2018, Abu Dhabi's nine desalination plants produced a total of 267,107 MIG (1,214 million m3) of water, averaging 732 MIGD (3.33 million m3/ day). Total gross production capacity in 2018 was 960 MIGD (4.36 million m3/ day). Some of this water was consumed at the production sites themselves (auxiliary consumption), while the rest was dispatched into the transmission system.

Independent Water and Power Producers (IWPPs) capacities and average daily production are depicted in Figure 1 below.

Figure 1: IWPP Capacity vs Average Daily Production in 2018



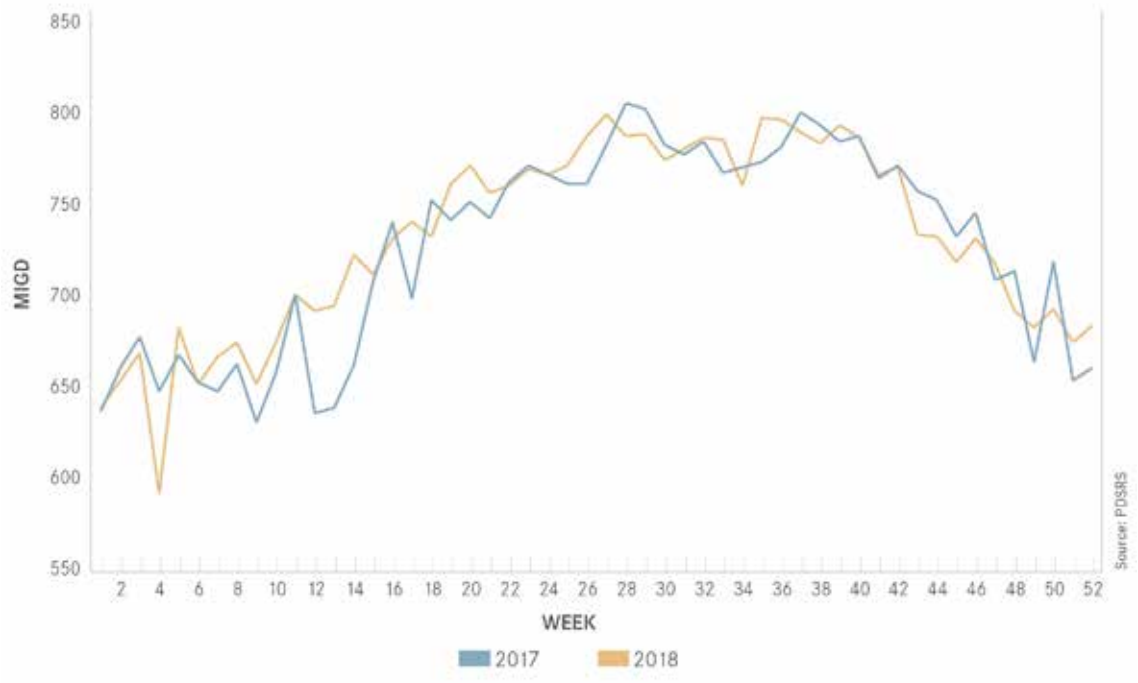
Water Demand Growth

The global water demand in 2018 peaked at 828 MIGD (3.76 million m3/ day), a negligible difference from 2017. The daily peak demand for the Emirate of Abu Dhabi dropped by nearly 2% from 2015.

Figure 2: Water Demand Growth

The weekly average water supply in 2018 is provided in Figure 3, presenting the seasonal variation in water demand.

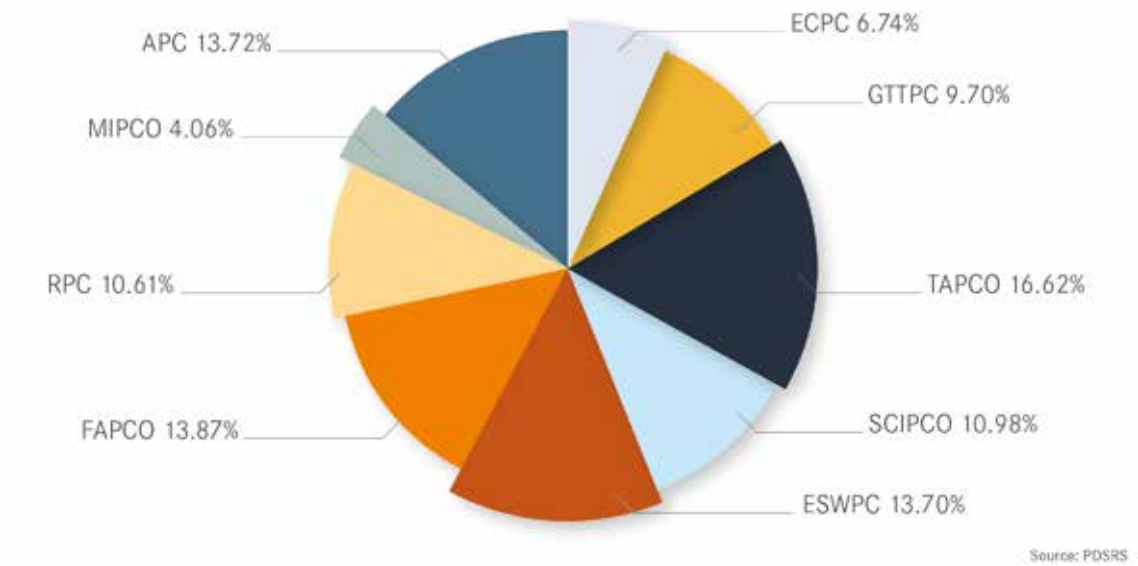
Figure 3: Average Gross Water Supply



Water Production by Company

In terms of water production market share, there are 9 desalination production plants with water production market shares ranging from 4 % up to 17% for 2018. Figure 4 below shows all IWPPs production market shares.

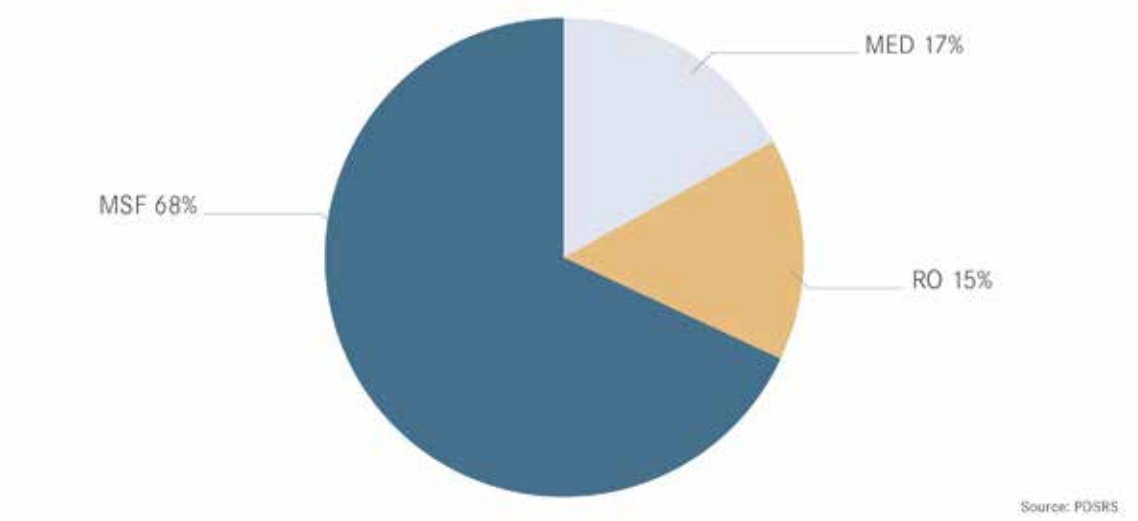
Figure 4: IWPPs (%) Share in Production in 2018



Water Production by Technology

Thermal desalination accounted for 85% of the water production in Abu Dhabi, predominantly via multi-stage flash (MSF) distillation, and to a lesser extent multiple effect distillation (MED) while the remaining 15% was generated by seawater reverse osmosis (RO).

Figure 5: Production by Technology

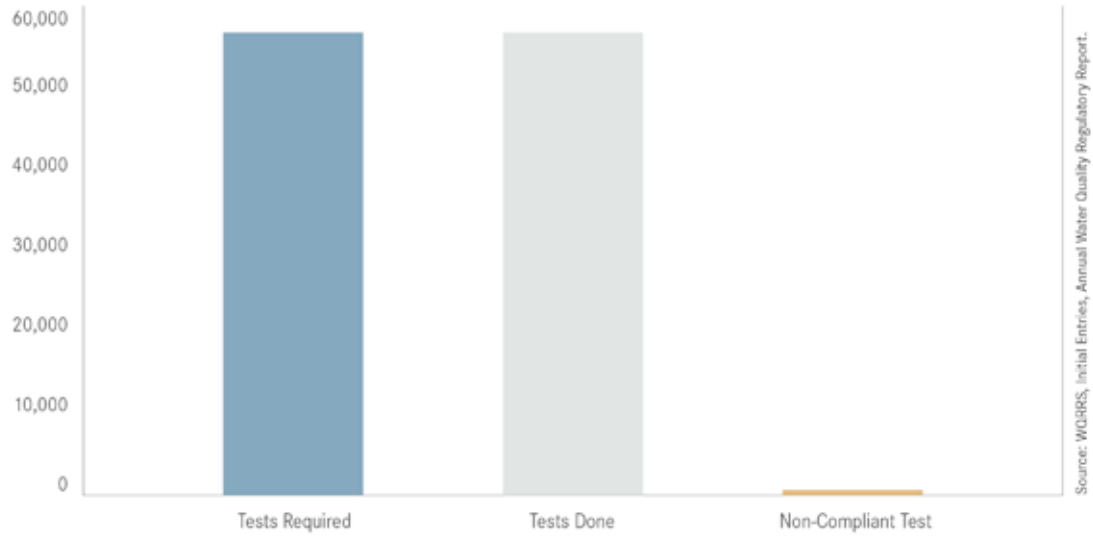


Water Quality Performance Measures - Production Companies Compliance

With respect to the production companies, the total number of tests completed is 57,249 with 64 water quality determinants (8 WQR's Tables) examined for RO and 51 water quality determinants examined for thermal (Testing for 7 WQR's Tables).

The overall compliance with the sampling frequency measure (SFM) was 100%, while prescribed concentration or value (PCV) compliance was 99.91%. The following charts illustrate the production companies' compliance with Water Quality Regulations (WQR) performance measures as follows:

Figure 6: Production Companies Water Quality Tests



Transmission

The transmission network transports large volumes of water from the production companies to the distribution companies. The sole transmission licensee in Abu Dhabi is TRANSCO. TRANSCO generates revenue from users via connection fees and Transmission Use of System (TUoS) where this tariff is reviewed annually by the DoE.

In 2018, the 3,601 km water transmission system carried a peak of 805 MIGD (3.66 million m3/day) of desalinated water via mains pipelines. These pipelines range in size from 500 to 1,600 mm in diameter and are made predominantly of cement-lined ductile iron (DI), Carbon Steel (CS) and partly Glass Reinforced Plastic (GRP). The drinking water transmission network comprises of 52 pumping stations with a combined capacity of 3,544 MIGD (15.71 million m3/ day), and 126 reservoirs with a total capacity of 664 MIG (3.02 million m3).

The total quantity of water leaving the network amounted to 257,597 MIG (1,171 million m3).

Table 1: Drinking Water Transmission Network Assets

Pumping Stations	Pumping Capacity (MIGD)	Reservoirs	Reservoirs Capacity (MIG)
52	3,544	126	664

Transmission System Performance

The performance of the water transmission system is measured through the following indicators developed by the DoE:

1 - Unaccounted water

2 - Security of supply

3 - System availability

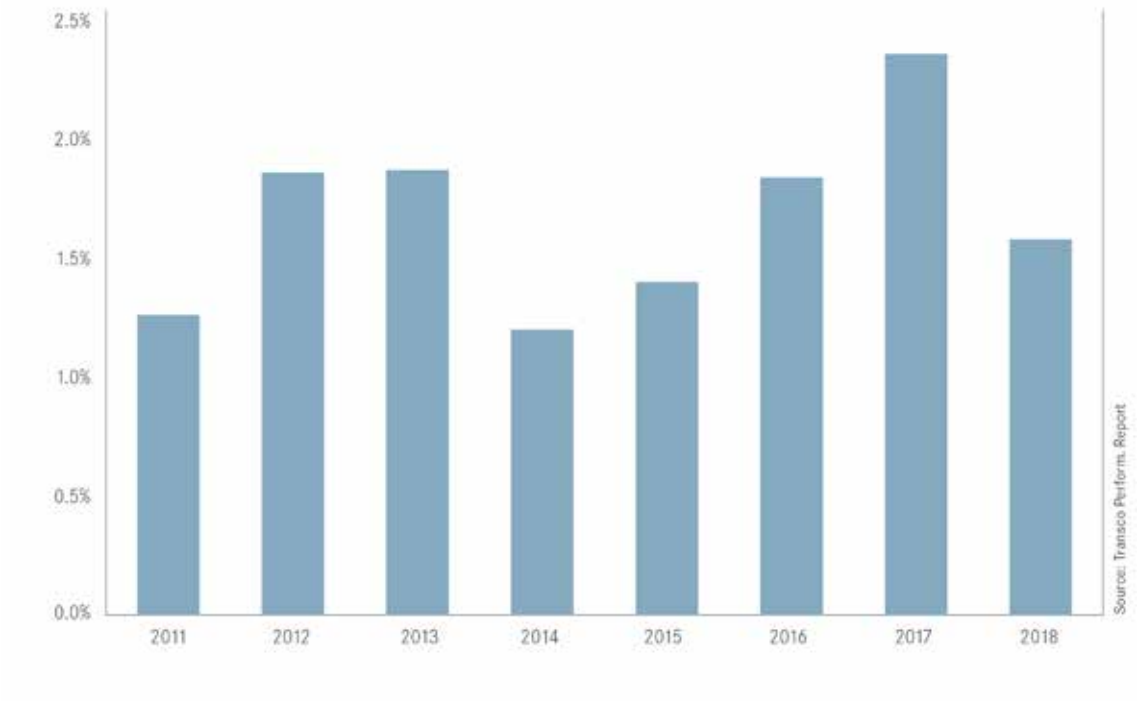
4 - Water Quality

1. Water Transmission Loss (Unaccounted Water)

Water transmission loss is the net difference between dispatched water from all producers, including wells, at the defined entry points (transmission network inflow) and the water delivered to distribution at the defined exit points (transmission network outflow). This method also takes into consideration the change in TRANSCO's reservoir water levels.

Figure 7 shows the percentage of water transmission losses from 2011 to 2018, which were below the 2% tolerance threshold, except for 2017.

Figure 7: Water Transmission Loss (%)



2. Security of Supply

The security of supply indicator measures reliability and efficiency, as well as flexibility in reacting to unforeseen demand events.

The security of supply is represented by the total "unsupplied" water that was dispatched to the distribution system at the connection points between TRANSCO and DISCOs.

The Distribution Companies (DISCOs) water demands may not be fully met for two reasons: first, in case of incidents where TRANSCO fails to supply the required quantities at the connection points (i.e. supply interruptions) and second; in cases where the DISCOs requirements have deviated from the scheduled quantities (i.e. unpredictable demand events).

Unpredictable demand events are where the DISCO's actual demand deviated from the scheduled quantity by a certain threshold. This deviation could be attributed to DISCO's forecasting errors, non-availability of metering data at some data management platforms (DMPs), or insufficient consumption profiling.

Figure 8 below shows the unpredictable demand events for both ADDC and AADC from 2010 to 2018. There are inherent difficulties in generating highly accurate demand forecasts, which requires further progress with data collection and validation, as well as network operational management. After a negative reversal of the trend in 2015 the number of such events have now stabilised and show signs of improvement.

Figure 8: ADDC vs. AADC Unpredictable Demand Events

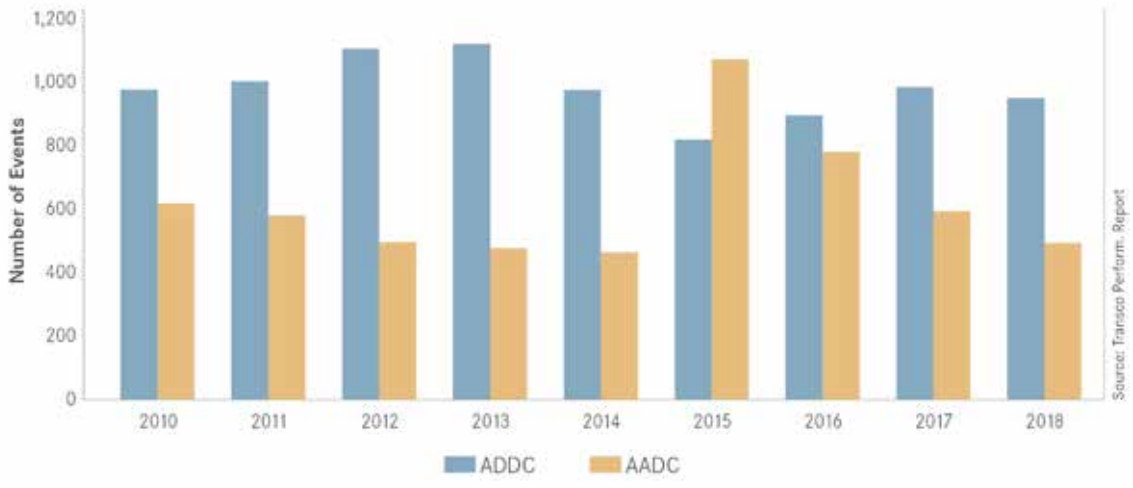
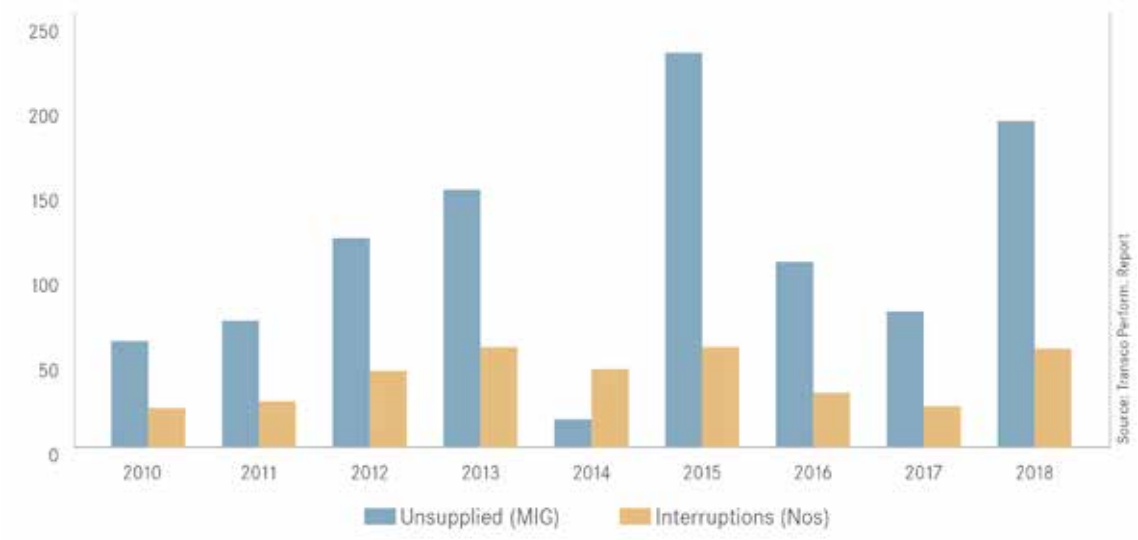


Figure 9 below shows the unsupplied quantities and interruptions caused by Transco. A positive trend of significant drop in unsupplied quantities and number of interruptions was achieved after 2015 by TRANSCO. 2018 witnessed an increase again primarily due to operational challenges resulting from the shutdown of some pumping stations in January 2018.

Figure 9: Unsupplied Quantities vs. Interruptions

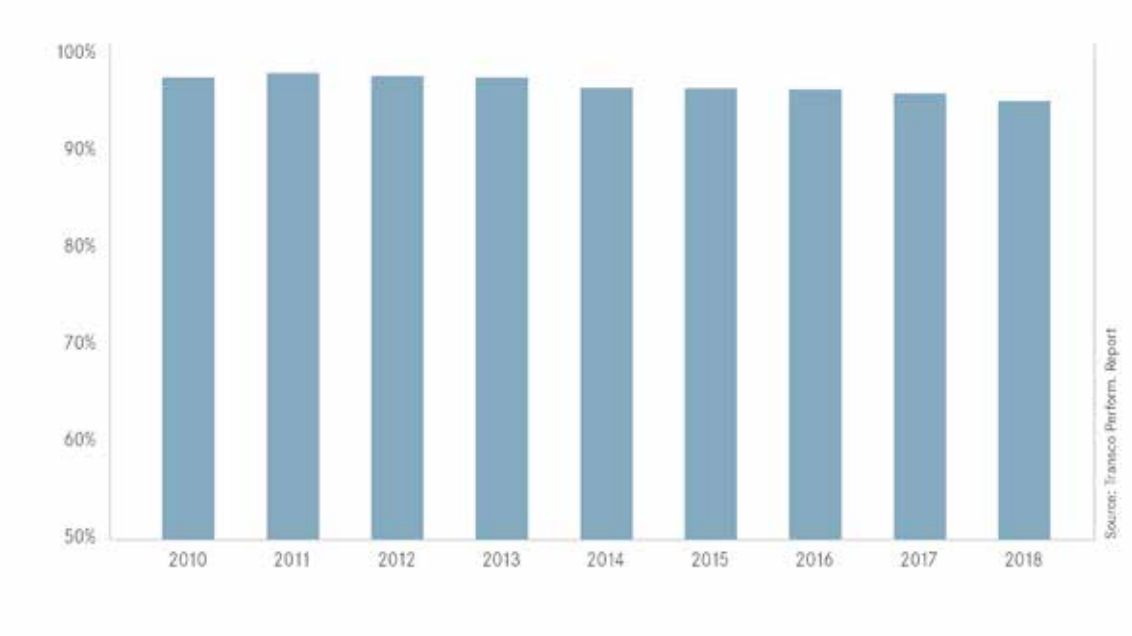


3. System Availability

This indicator determines the proportion of components (pumps, transmission lines, storage tanks, surge vessels, or combination thereof) that are either operational or available for use during a given period. Components that do not meet this definition are classed as “unavailable”.

Transmission System Availability has remained relatively steady and positive since 2010; TRANSCO’s overall system availability in 2018 is 95.27%, as illustrated in Figure 10 below. The component most often found to be responsible for unavailability was pumps (just over 95% in 2018). The DoE works closely with TRANSCO to enhance the assets condition and performance monitoring activities.

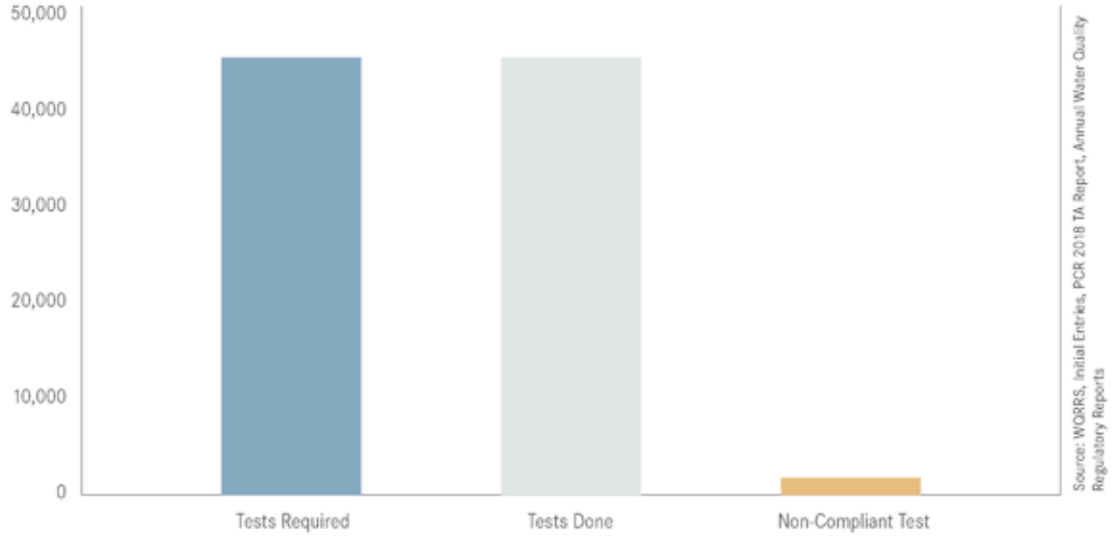
Figure 10: Transmission System Availability



Water Quality Performance Measures - TRANSCO Compliance

With respect to TRANSCO, the total number of tests performed was 45,739 (6,046 tests were excluded due to non-operational conditions in LARS and PS1 low pressure pipeline from AADC to Zakher) with 62 water quality determinants examined for the transmission system (Testing for 7 WQR's Tables).

Figure 11: Transmission Water Quality Tests



Following the WQR's (Fourth Edition) Schedules 1 and 2 amendments TRANSCO was required to lay the foundations and cornerstone of testing and sampling for legionella parameter from 1 January 2018.

The overall compliance with the sampling frequency measure (SFM) was 100%, while prescribed concentration or value (PCV) compliance was 99 %.

Distribution

The total length of the distribution system operated by Al Ain and Abu Dhabi distribution companies (AADC and ADDC) is about 13,951 km, which is predominantly composed of cement-lined DI pipelines ranging in diameter from 80 to 1,200 mm, with high density polyethylene pipe lines also increasingly being installed. The network comprises a total of 43 pumping stations with an overall capacity of 95 MIGD (0.43 million m3/day) and 99 reservoirs with total capacity of 64.5 MIG (0.29 million m3).

Table 2: Drinking Water Distribution Network Assets

	Pumping Stations	Pipelines (km)	Reservoirs
AADC	8	4,872	14
ADDC	35	9,079	85
Total	43	13,951	99

In 2018, the average daily water supply to Abu Dhabi was 477 MIGD (2.17 million m3/day) and to Al Ain 177 MIGD (0.8 million m3/day), based on weekly averages, as illustrated in the graphs below. This has been consistent with the weekly water supplied in 2017.

Figure 12: Water Supply/Consumption – Abu Dhabi

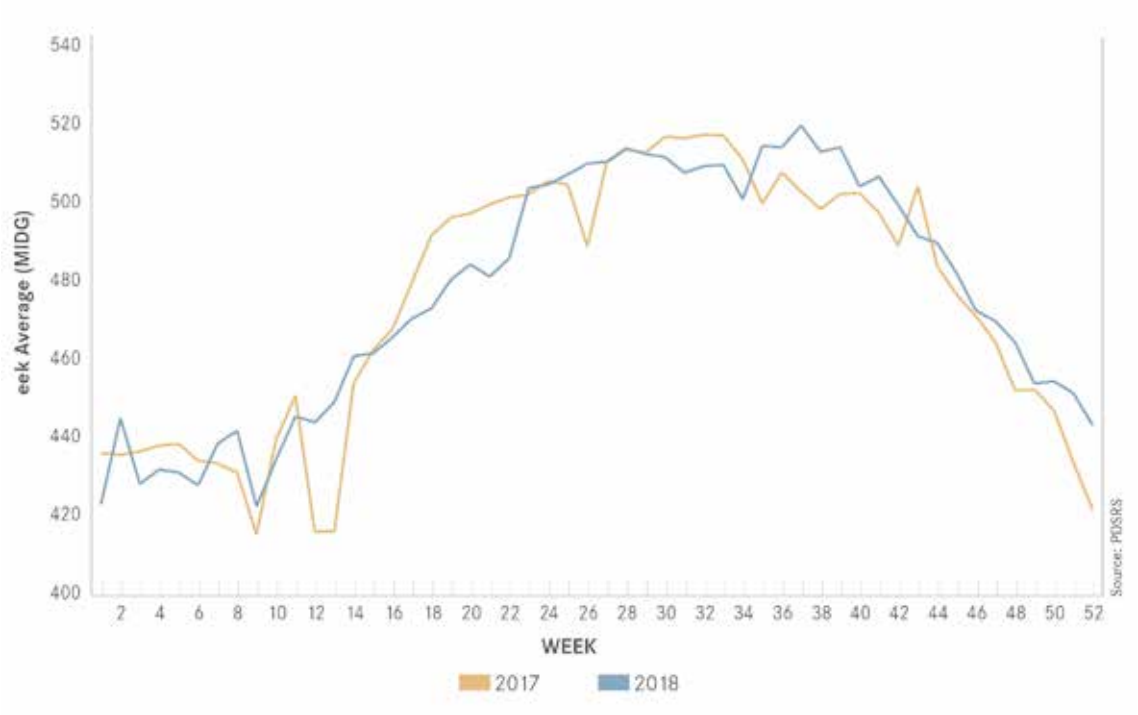
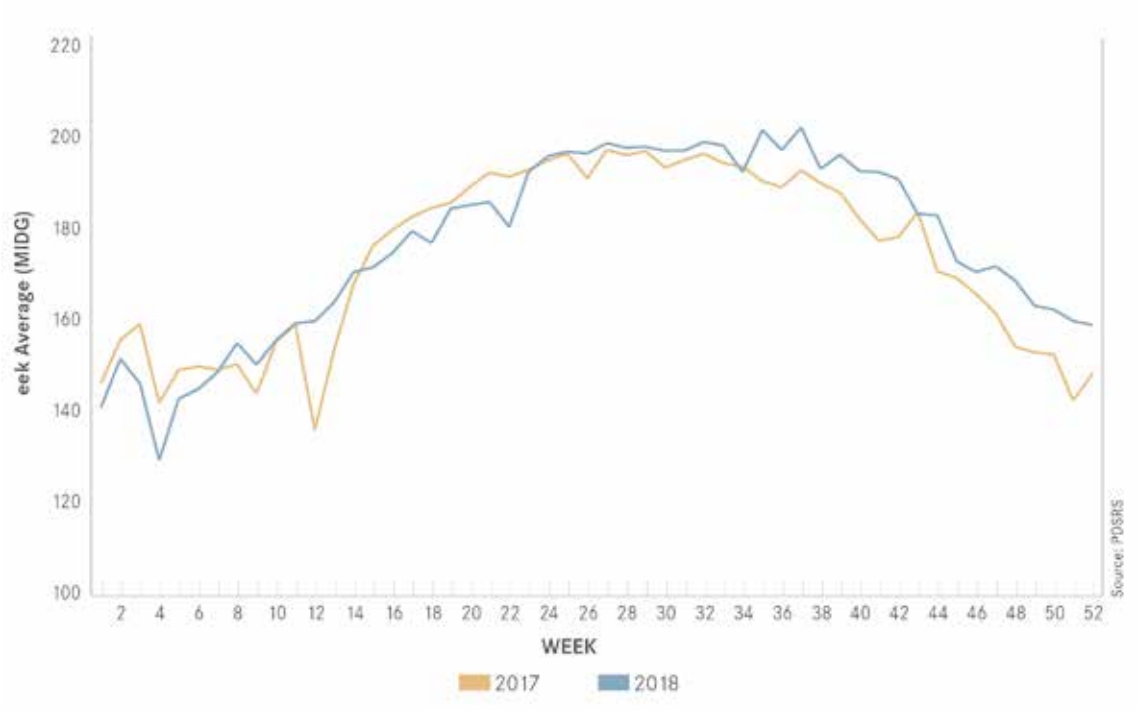
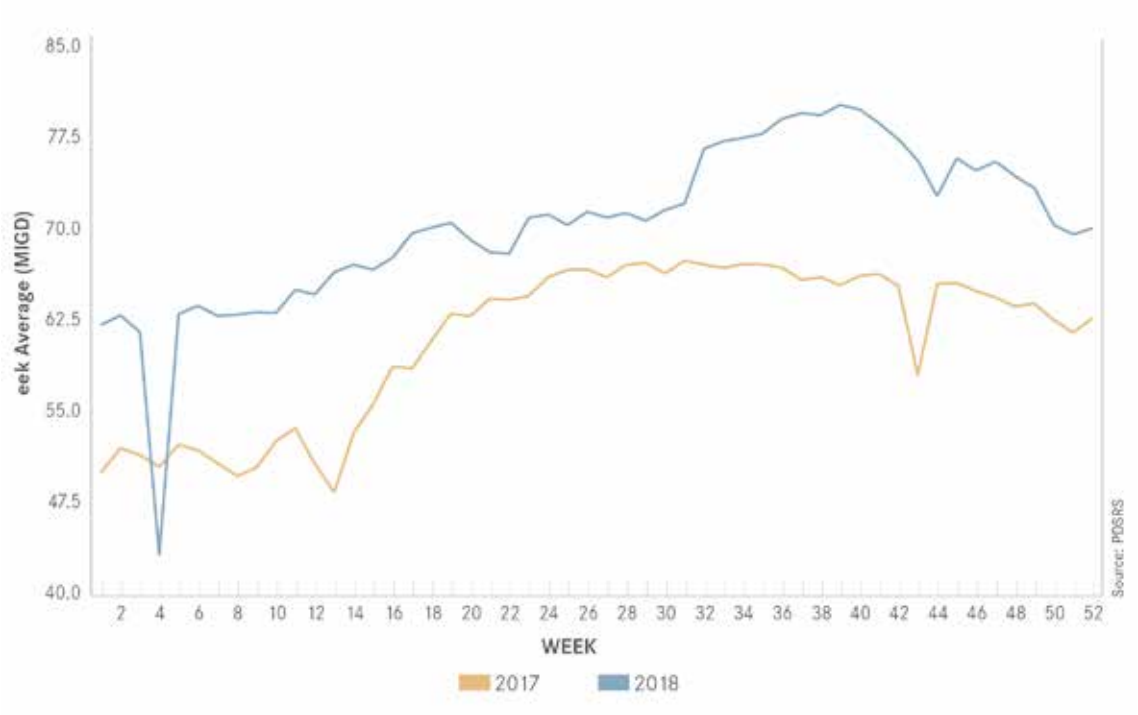


Figure 13: Water Supply/Consumption - Al Ain

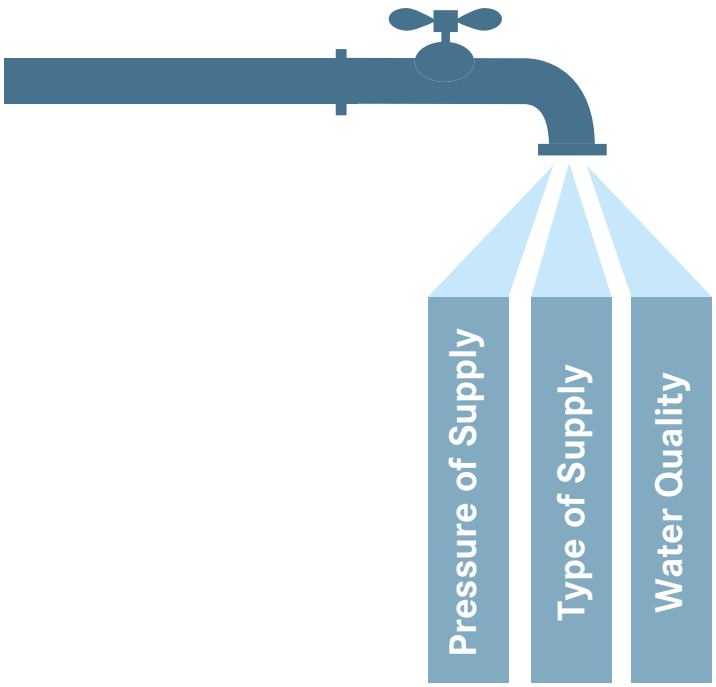


In 2018, the average daily water supply to the Northern Emirates was 71 MIGD (0.32 million m3/day), representing an increase of 16% over 2017, as illustrated in the graph below.

Figure 14: Water Supply/Consumption – Northern Emirates



The performance of the water distribution system is measured using various indicators developed by the DoE, including:



Pressure of Supply

Pressure of Supply measures supply pressure with a view to achieving a standardised level sufficient to supply low-rise buildings, thereby reducing reliance on ground storage tanks and preventing infiltration by ground water contaminants.

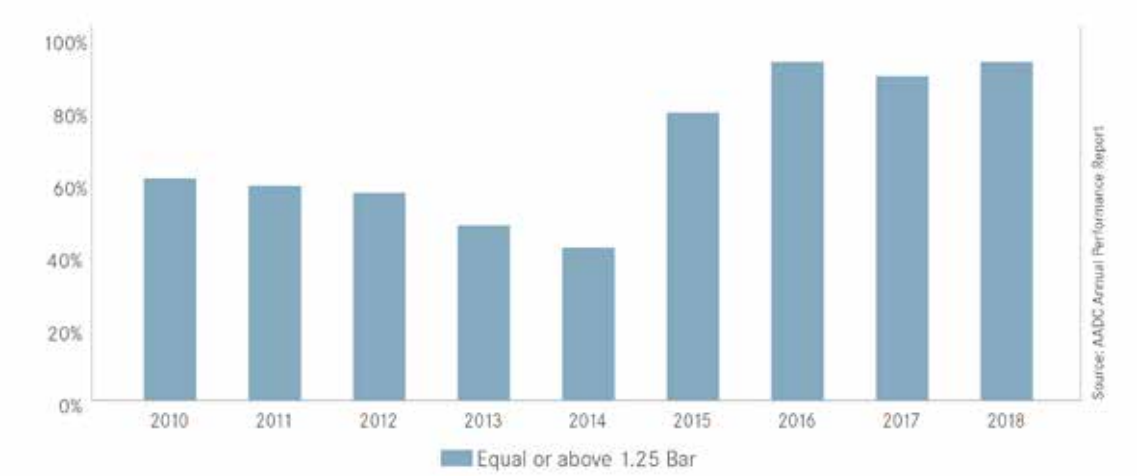
In line with the Water Supply Regulations the minimum required pressure in the distribution network is 1.25 bar. In 2018, compliance with this requirement increased to 92% in Abu Dhabi and 93% in Al Ain, as shown in Figure 15 and 16 below. The ultimate goal is to achieve 100% compliance.

With respect to ADDC, the majority of the noncompliant cases are recorded in the Central Region and are attributed to pressure restriction at the interfaces with TRANSCO. This pressure restriction is due to the poor condition of some pressurised Ring Mains/Sector Mains on Abu Dhabi Island (condition assessment has concluded that these assets are priority no. 1 under ADDC Asset Replacement Plan). Following this condition assessment, ADDC has identified asset replacement projects in their 5 year Capital Investment Plan.

With respect to AADC, non-compliance cases are mainly due to distribution constraints. TRANSCO completed all of their projects in Q4 2016 thereby lifting transmission constraints. AADC completed the majority of the asset replacement programme identified in light of the condition assessment exercise. There remains some Discrete Metered Areas (DMAs) in the southern region of Al Ain where continuous pressurisation will commence soon.

Figure 15: Pressure of Supply – ADDC

Figure 16: Pressure of Supply – AADC



Type of Supply

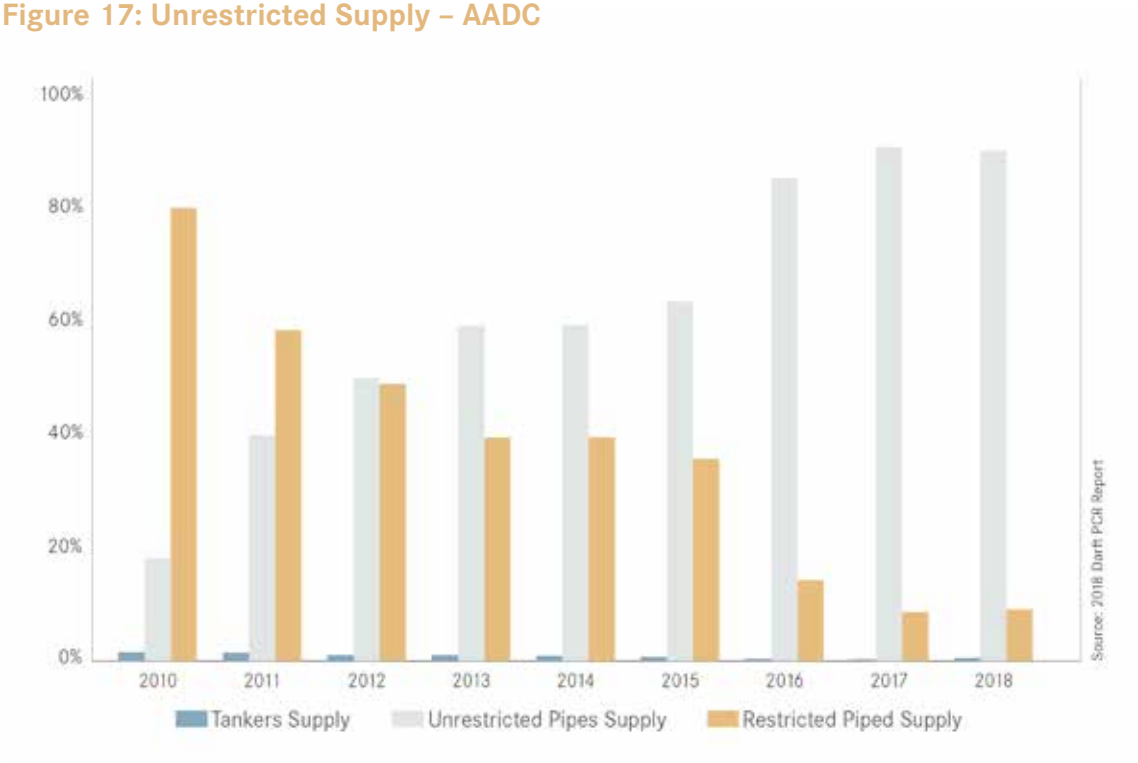
This indicator gauges the progress made towards reducing the number of customers dependent on tankers and intermittent supply.

For ADDC the proportion of customers connected to the network stands at 99.60%, with 99.45% on continuous supply and 0.15% on intermittent supply, while the remaining customers (0.40%) are supplied with drinking water by tankers.

The situation in AADC has been steadily improving and around 99.44% of AADC's customers are now connected to the network with 90.31% on continuous supply and 9.13% on intermittent supply. The remaining customers (0.56 %) are supplied with drinking water by tankers.

The Figure 17 below shows the decrease in unrestricted supply in Al Ain during 2018.

Figure 17: Unrestricted Supply – AADC



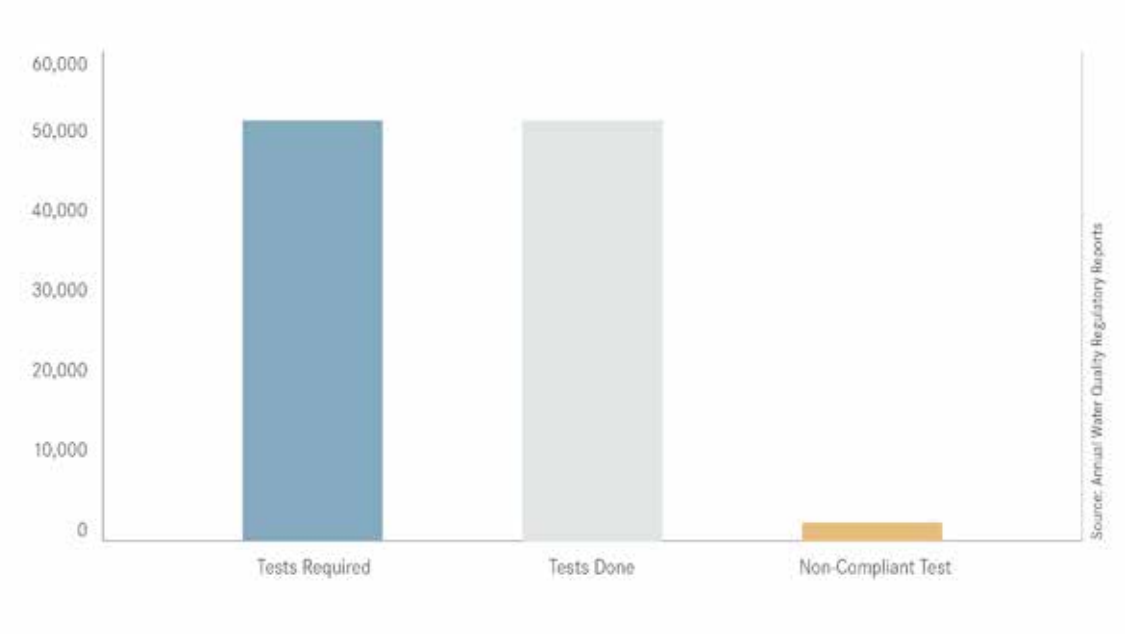
Water Quality Performance Measure - Distribution Companies Compliance

With respect to ADDC, the total number of tests performed was 52,644 with 64 water quality determinants examined for the distribution system (Testing for 8 WQR's Tables).

Following WQR's (Fourth Edition) Schedules 1 and 2 amendments, ADDC was required to lay the foundations and cornerstone of testing and sampling for legionella parameter from 1 January 2018.

The overall compliance with the sampling frequency measure (SFM) was 100%, while prescribed concentration or value (PCV) compliance was 96 %. Figure 18 below illustrates the ADDC's compliance with the WQR performance measures as follows:

Figure 18: ADDC Compliance with Water Quality Tests

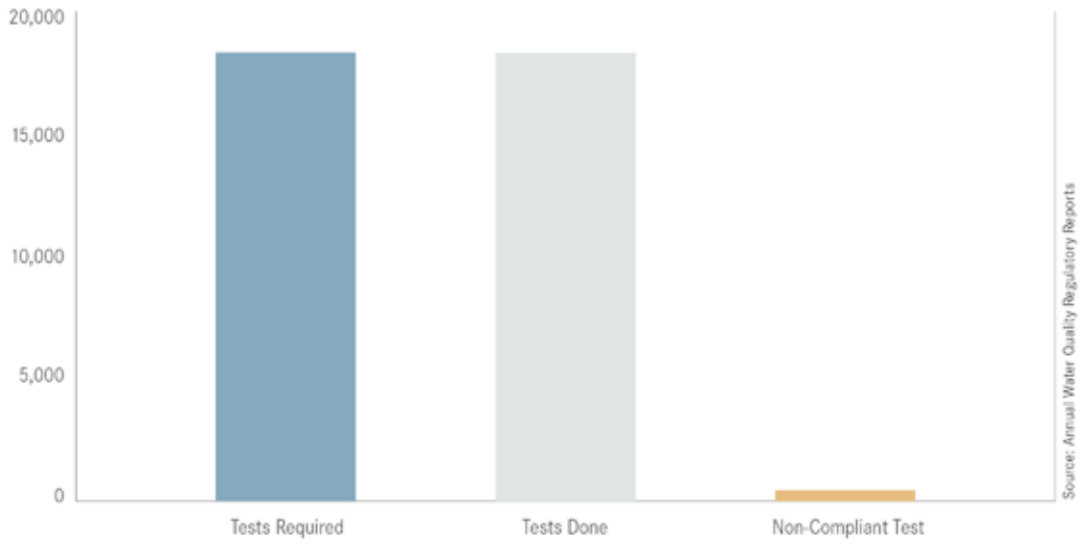


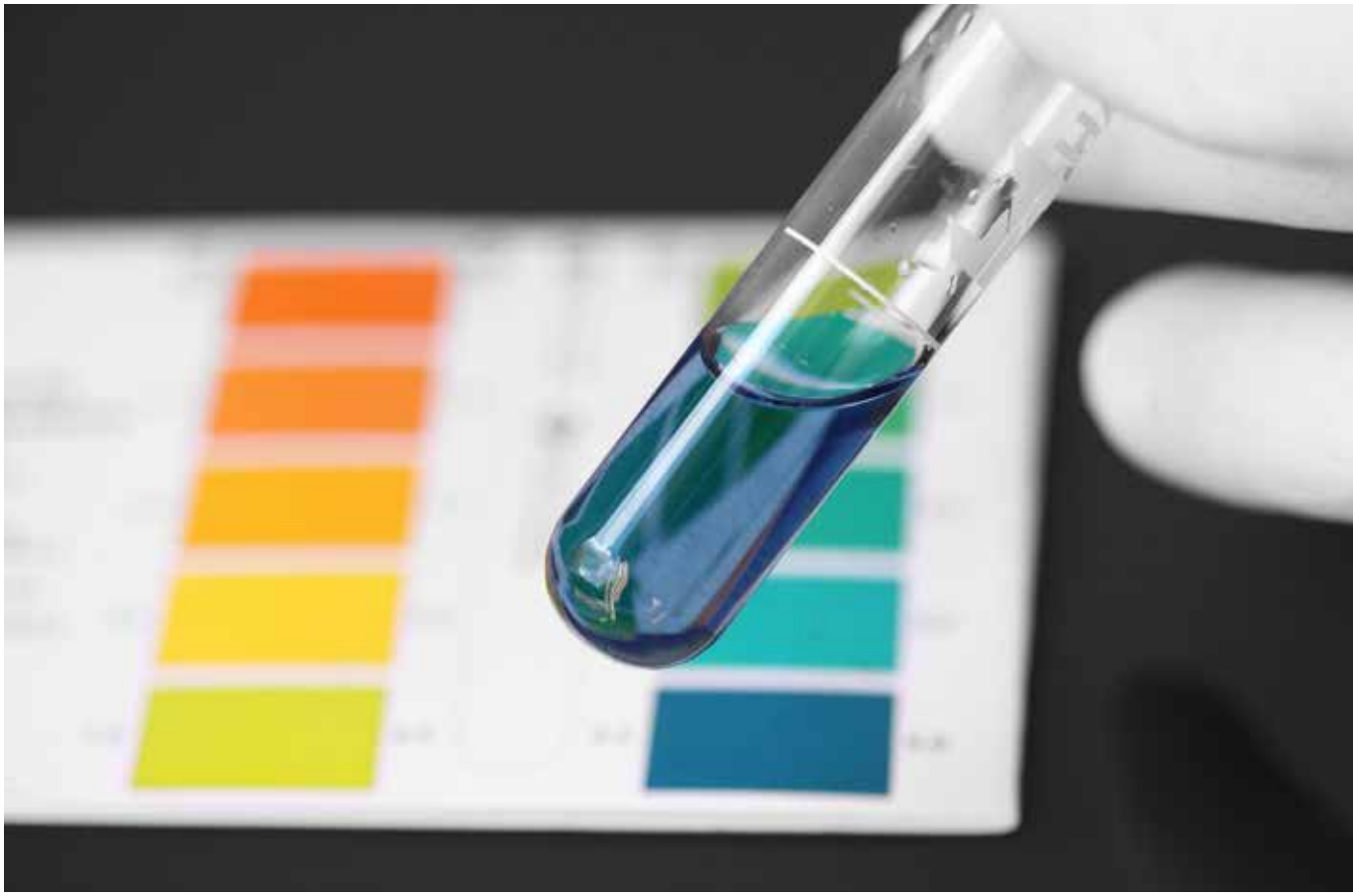
With respect to AADC, the total number of tests performed was 18,713 with 64 water quality determinants examined for the distribution system (Testing for 8 WQR's Tables). Eight water quality tests could not be performed in the Central Region and one in the Northern Region.

Following WQR's (Fourth Edition) Schedules 1 and 2 amendments and changes reflected in regulatory submissions in regards to regulatory compliance, AADC was required to lay the foundations and cornerstone of testing and sampling for legionella parameter from 1 January 2018.

The overall compliance with the sampling frequency measure (SFM) was 100%, while prescribed concentration or value (PCV) compliance was 98 %. The regulatory complaint tests were 98% of the total tests performed. The following chart illustrates AADC's compliance with WQR performance measures as follows:

Figure 19: AADC Compliance with Water Quality Tests

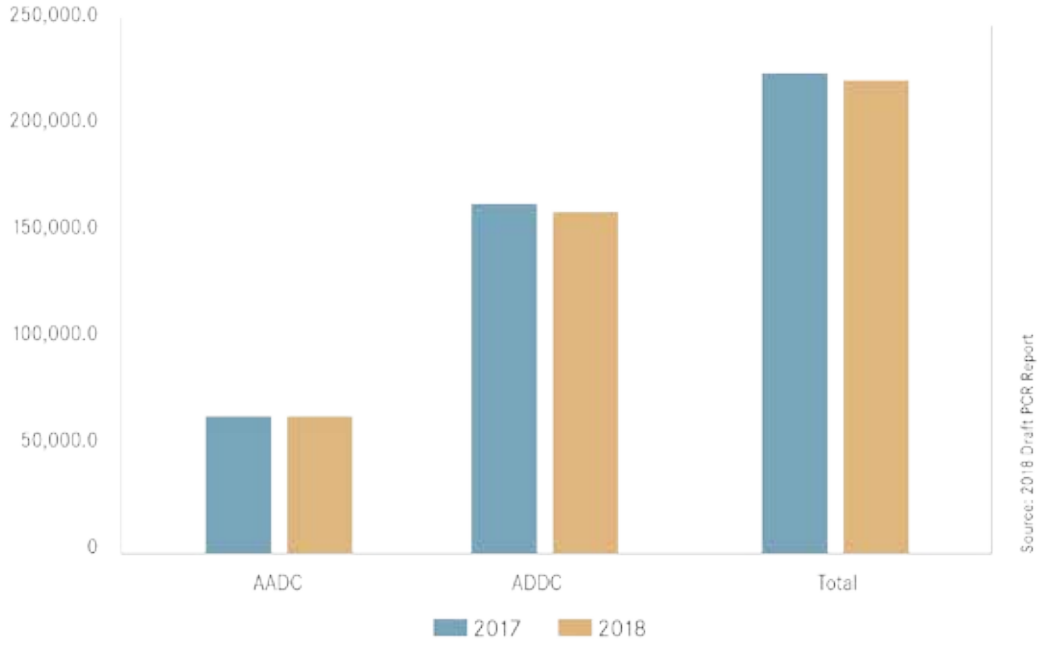




Drinking Water Consumption

Water sector witnessed a steady growth in 2018. Water consumption in 2018 in Abu Dhabi remained stable in comparison to 2017. The total consumption reached 219,946 MIG (999.9million m3) in 2018 compared to 223,228 MIG (1,015 million m3) in 2017.

Figure 20: Water Consumption Comparison



Production:
12 Power Providers
16,622 MW Capacity
84,182 GWh Generation

Transmission:
155 Grid Substations: 400, 220 and 132kV
69,605 MVA Capacity
994 KM of Underground Cables
8,222 KM of Overhead Lines

Distribution:
531,951 connected customers
447 Primary Substations
34,737 Distribution Substations
70,394KM of cable/overhead lines

4. Electricity

Generation

Executive Summary

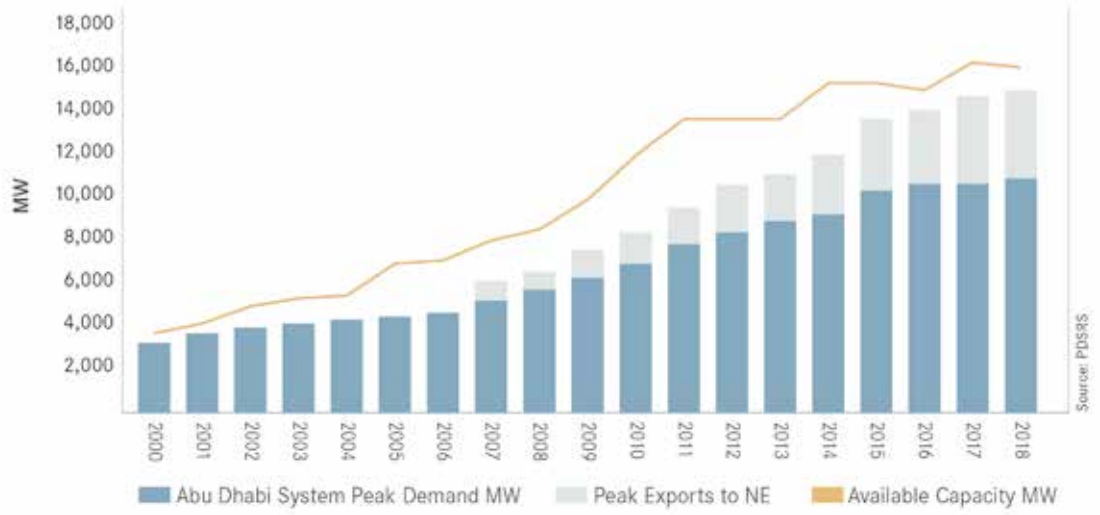
Demand for electricity in the emirate of Abu Dhabi continued to grow during 2018. Global electricity demand (Abu Dhabi and exports) peaked at 15,125 MW on 11th July 2018, an increase of 2.3 % year on year. As a result, the sector generated 84,182 GWh of electricity during 2018, an increase of 1.4% of electricity from last year.

Abu Dhabi electricity generation assets have an available capacity of 16,622 MW.

Electricity Generation

In general, the Abu Dhabi system peak reached its demand at 11,080 MW on 11th July with an increase of 1.9 % from last year (10,876 MW). Likewise, 11th July also witnessed the highest global demand for electricity for 2018, which reached 15,125 MW with an increase of 2.3 % from last year (14,788 MW). Abu Dhabi export to Northern Emirates reached its peak on 16 August with an increase of 2.2 % from last year (4,012 MW).

Figure 21: Electricity Demand Growth (MW)



To support such demand for electricity, Abu Dhabi has an array of conventional and CCGT plants in addition to a CSP plant (SHAMS 1) which was commissioned in 2013 and located in Madinat Zayed, Abu Dhabi with a 100 MW generating capacity.

Table 3: Global Electricity Capacity & Generation – 2018

	Capacity (MW)	Generation (GWh)	Technology
AMPC	365	61	OCGT
APC	1,991	11,798	Co-gen
ECPC	760	5,525	Co-gen
FAPCO	2,114	8,592	Co-gen
GTTPC	1,671	10,339	Co-gen
MIPCO	1,702	5,844	Co-gen
RPC	1,627	10,404	Co-gen
SAPCO	1,647	7,877	Co-gen
SCIPCO	1,615	8,958	Co-gen
SEMBCORP	861	3,004	CCGT
SHAMS	50	233	CSP
TAPCO	2,220	11,546	Co-gen
Total	**16,622**	**84,182**	

In terms of production generation markets, there are 12 power providers with electricity generation market shares ranging from 0.3 % up to 14% for 2018. Figure 22 below shows all IWPPs generation market shares.

Figure 22: Electricity Generation by Company

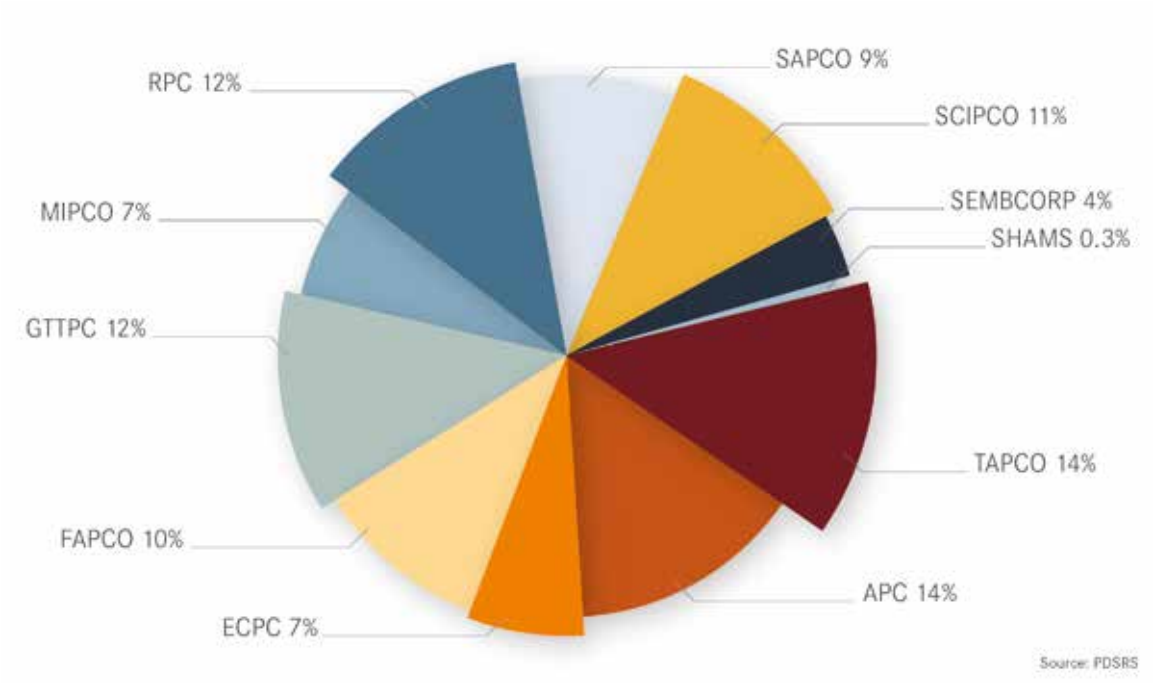
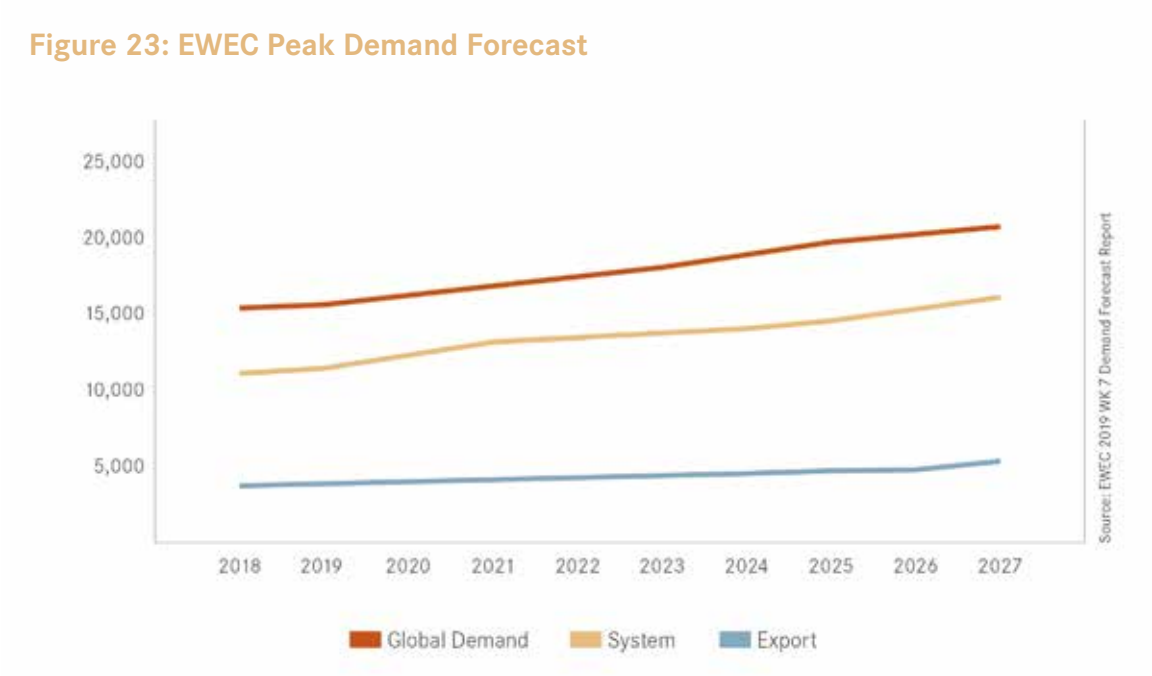


Figure 23 below shows the Emirates Water and Electricity Company (EWEC) demand forecast approved in 2018 for the sector peak demand up to year 2027. The system demand (excluding exports) is expected to increase from 11.4 GW in 2019 to 15.6 GW in 2027, while the global peak (including exports) is expected to increase from 15.57 GW in 2019 to 20.69 GW in 2027.

Figure 23: EWEC Peak Demand Forecast



Natural Gas remained the predominant fuel type used within the sector to generate electricity and produce water in Abu Dhabi. Both ADNOC and DEL continued supplying the sector with natural gas throughout the year without the need to burn any back-up-fuel more than the regular amounts used to carry out operational tests to maintain liquid fuel supply system ready on standby if needed. It is reported that both ADNOC and DEL have delivered around 819,922,319 BBTU of natural gas to the sector, which is 0.9% less than last year (827,173,668 BBTU).

System Performance

Available plant capacity was maintained with reasonable capacity margin throughout the year. Most of the generation plants reported high reliability index. The average load factor throughout the year was 62%. This factor represents the actual generation to the generation capacity which was available to the sector.

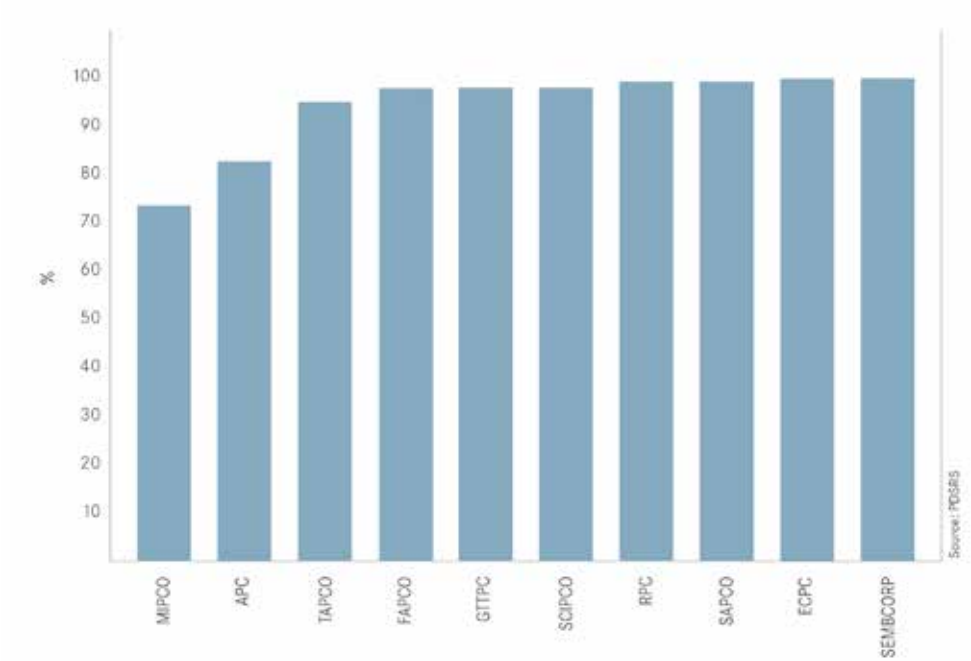
Table 4 below shows the plant year average reliability (electricity generation) and the desalination average plant performance ratios.

Table 4: Plants Performance - 2018

IWPP	Reliability
APC	82
ECPC	100
FAPCOA	98
GTTPC	98
MIPCO	73
RPC	99
SAPCO	99
SCIPCO	98
SEMBCORP	100
TAPCO	95

Figure 24 below shows plants reliability percentage for 2018 as reported by the plants. APC results are mainly influenced by the lower performance of the aging of the assets.

Figure 24: Plant Reliability % - 2018



Transmission

The transmission network transports large volumes of electricity from the production companies to DISCOs.

The sole licensee in the Emirate of Abu Dhabi is TRANSCO.

TRANSCO generates revenue from users via connection fees and transmission Use of System (TUoS) tariff that is reviewed annually by the DoE.

The table below shows the up to date assets for TRANSCO.

Table 5: TRANSCO Assets

Grid Substations	Capacity	Underground Cables	Overhead Lines
155 (220, 400 and 132 KV)	69,605 MVA	994 km	8,222 km

System Performance

Transmission Network Unavailability

System unavailability is defined as the ratio of the unavailable circuit hours and the total system circuit hours. The total unavailability increased from 0.67 in 2017 to 0.92 in 2018 as shown in the graph below. Analysis of the data indicates that there was an increase in maintenance outages in 2018 compared to 2017. Overall system availability is above 99%. It is to be noted that TRANSCO is incentivised if the availability is greater than 98.5% and penalised if the availability is below 97.5% with zero incentive for the dead band (97.5% - 98.5%)

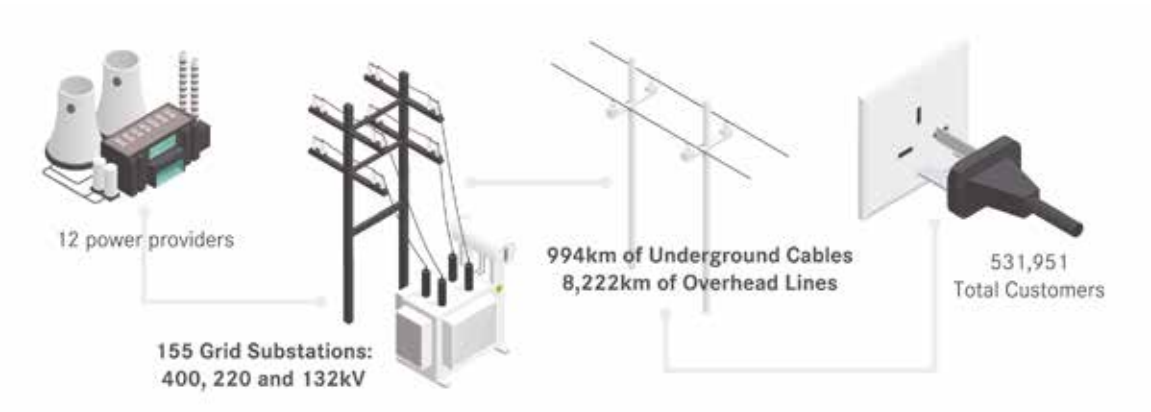
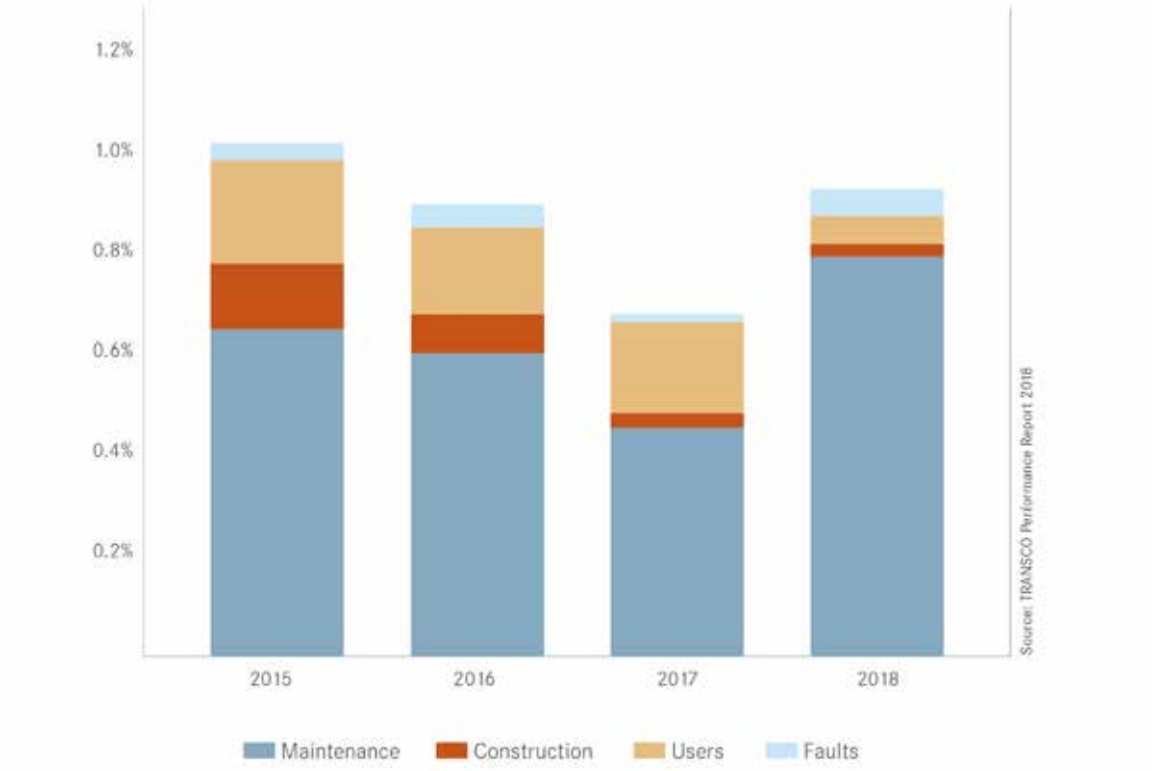


Figure 25: Transmission System Unavailability

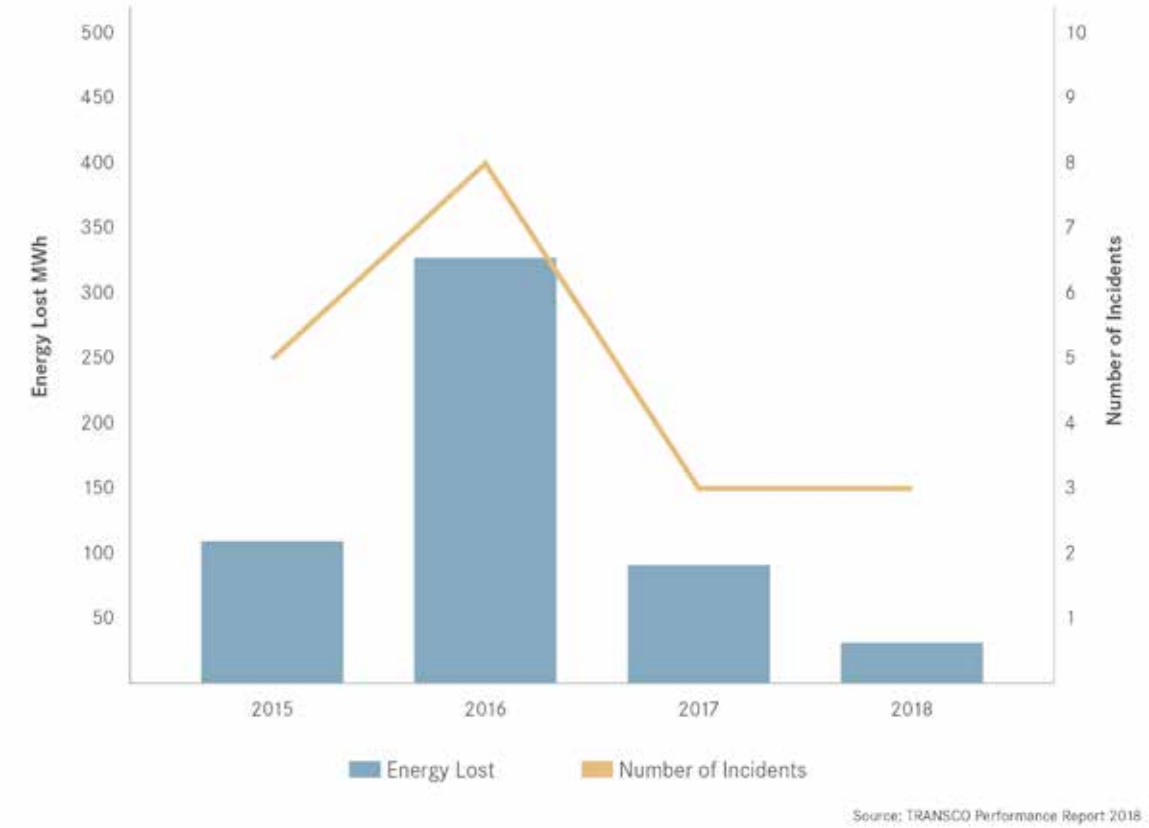


Unsupplied Energy

The impact of loss of supply resulted from transmission incidents is quantified in terms of energy lost "unsupplied energy" which is calculated by taking into account the size and duration of the demand lost, expressed in MWh. In 2018 there were three transmission incidents, resulted in the loss of 31.78 MWh of unsupplied energy (a reduction of approximately 60 MWh from the previous year), which is shown in the graph below. It is to be noted that the unsupplied energy target in RC1 is zero and TRANSCO is penalised for any unsupplied energy.

In addition to the above, there were three exceptional incidents on the transmission system due to faults on the user system which resulted in the loss of about 91 MWh of unsupplied energy it is to be noted that such incidents are excluded from TRANSCO RC1 losses calculation.

Figure 26: Transmission System Incidents and Energy Lost

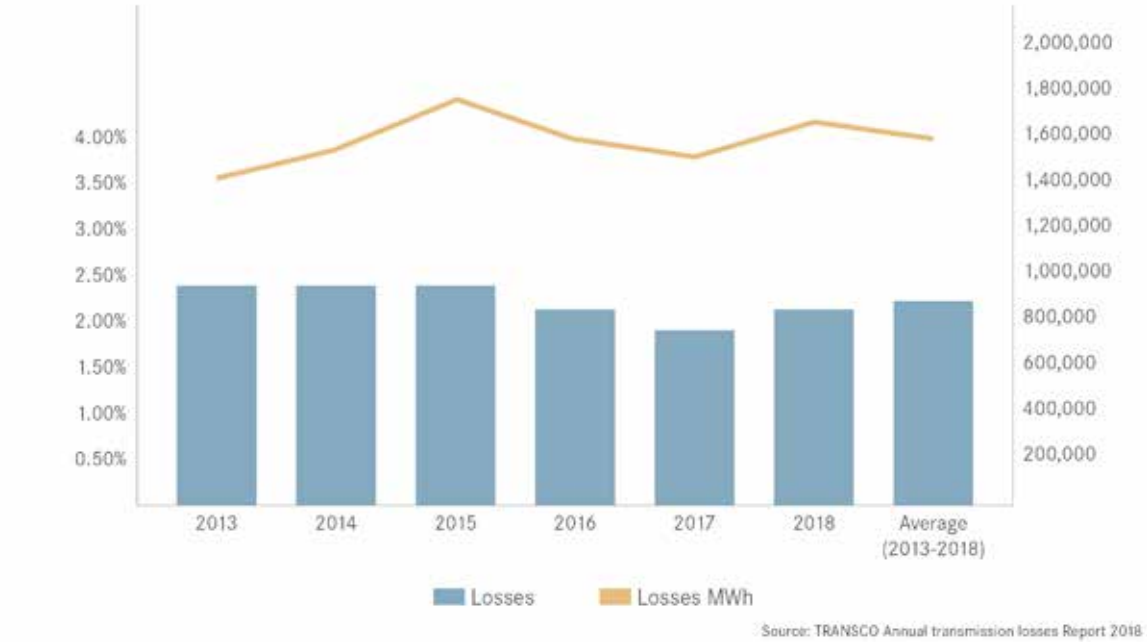


Transmission System Losses

Energy loss in the transmission system is mainly due heat dissipation as a result of electricity flow in the different parts of the network “overhead lines, cables and transformers”. System losses are measured as the difference between the total energy input to the transmission system and total energy output from the transmission system.

Transmission losses increased slightly from 1.97% in 2017 to 2.13% in 2018 which is below the average losses 2013-2018 (2.28%). Currently there is no penalty for transmission losses in RC1.

Figure 27: Transmission System Losses



Quality of Supply

Based on licence requirements, TRANSCO annually reports the quality of power supply delivered in terms of steady state voltage variation, voltage unbalance and voltage flickering. TRANSCO also reported transient voltage and frequency disturbances during abnormal system conditions. The tables (6) and (7) below show the steady state 400kV voltage and frequency which remain within the limits in the electricity transmission code. Currently there are no incentives in RC1 for the quality of supply.

Table 6: Voltage Profile – 400 kV Network

	Voltage (kV)	Deviation (%)	Std. Limit
Max	414.46	3.61%	
Min	382.61	-4.35%	±5%
Avg.	407.07	1.77%	

Table 7: Trend of System Frequency Variation – 400 kV Network

	Freq. (Hz)	Freq. (ΔF%)	Std. Limit
Max	50.06	0.12%	IEC61000-2-4 ±1%
Min	49.97	-0.06%	
Avg.	50.01	0.02%	

Distribution

The table below gives an indication of the number of electricity customers and asset base of AADC and ADDC in 2018.

Assets

	ADDC	AADC	Total
Number of Electricity connected customers	380,268	151,683	**531,951**
Number of Primary Substations	286	161	**447**
Number of Distribution Substations	19,007	15,730	**34,737**
KM of cable/overhead lines	42,414	27,980	**70,394**

Peak Demand Growth:

ADDC ↑1.2%
AADC ↑4.5%

Peak Demand

The peak demand load of ADDC grew by 1.2% from 2017 to reach 6,027 MW in 2018, while that of AADC grew by 4.5% to reach 2,321 MW.

Figure 28: ADDC Peak Demand Load

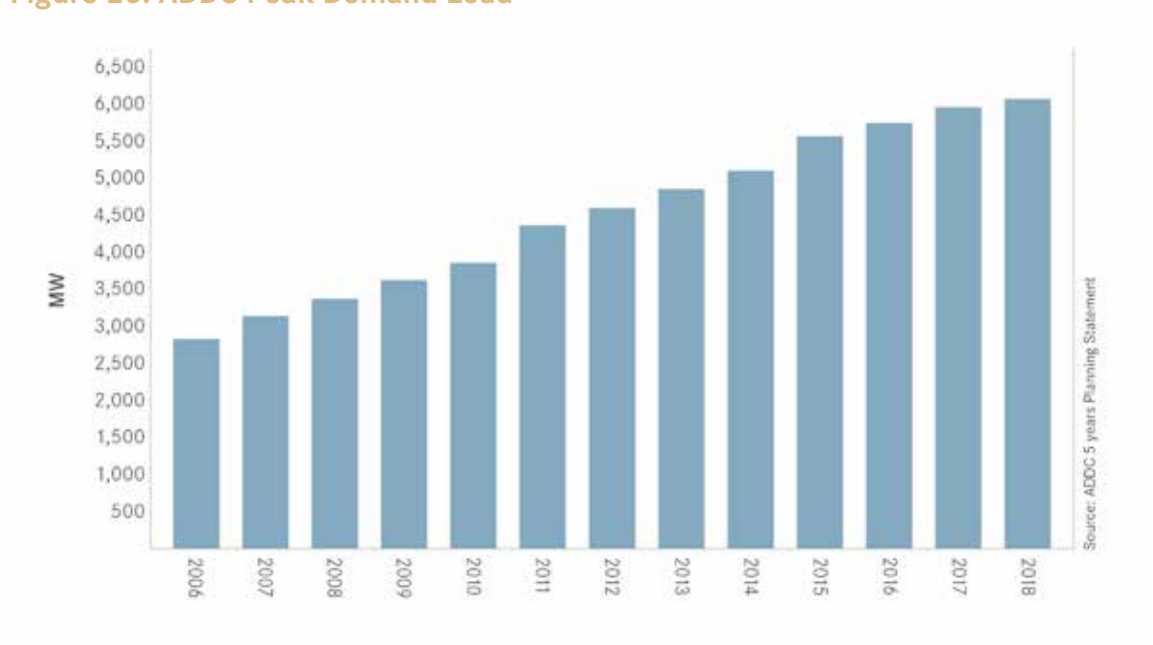
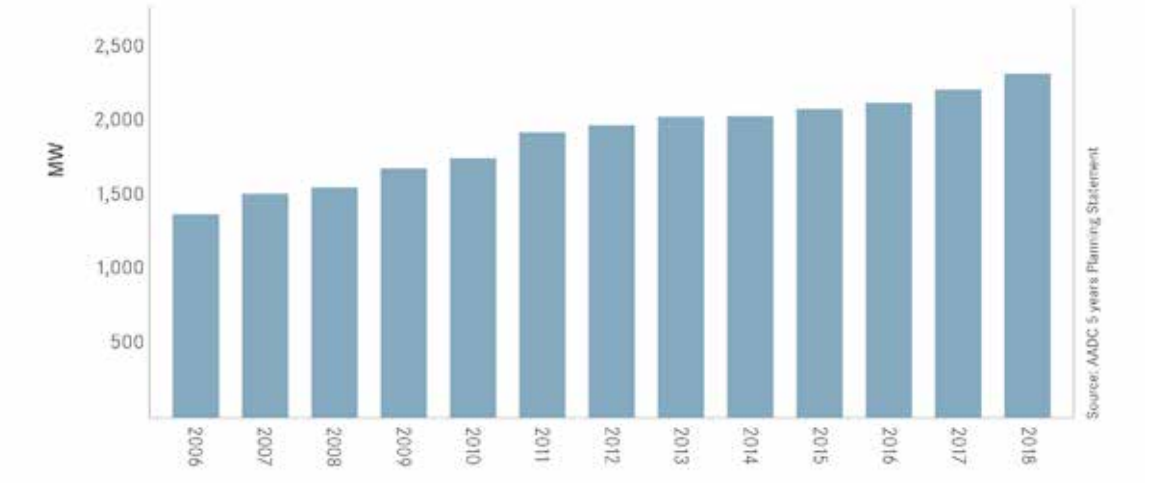


Figure 29: AADC Peak Demand Load



Performance

SAIDI, the System Average Interruption Duration Index is calculated as the sum of customer minutes lost experienced during the year due to interruptions in the network divided by the number of customers. It gives an indication of the average duration of interruption experienced by a customer over the year.

SAIFI, the System Average Interruption Frequency Index is calculated as the sum of the number of customers affected by interruptions during the year divided by the number of customers and gives an indication of the average number of interruptions experienced by a customer over the year.

While these two KPIs measure averages over the year, any major interruptions which have a large contribution to SAIDI and SAIFI are reportable under the Incident Reporting Regulations and are investigated accordingly.

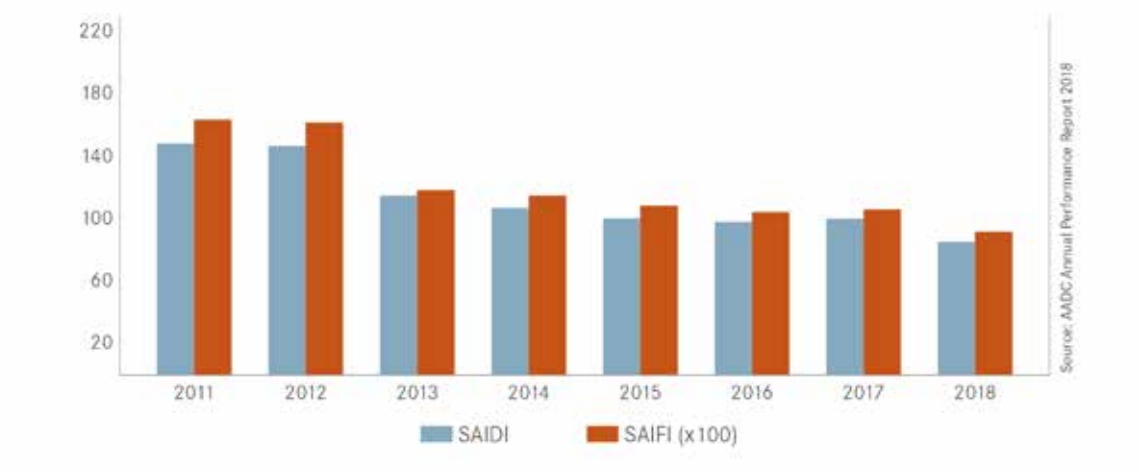
The 2018 SAIDI and SAIFI figures for both ADDC and AADC decreased by between 14% and 16% from the 2017 figures.

This has been the largest improvement since 2014 for ADDC and is attributed to the reduction of the impact of incidents in Al Dhafra region, largely due to ADDC's efforts in the past few years on the rehabilitation of the network there.

Similarly for AADC, this has been the largest improvement since 2013 and it is due to a significant reduction in the impact of weather related incidents as cited by ADDC in their Annual Performance Report.

Figure 30: ADDC Power Interruption

Figure 31: AADC Power Interruption



Losses

Electricity losses are measured by the difference between the units entering the system and those leaving it.

The 2018 losses for both ADDC and AADC have improved due to improvements in the calculation methodology in terms of accuracy.

Figure 32: Electricity Losses

Collection:
404,418 Connected Customers

1,260 Off Network Customers

110 consented trade effluent entities

Wastewater collected 2018:
311,858 Ml/year, 855 Ml/day

Assets:
8,447 km collection network

Treatment:
Assets:
39 sewage treatment plants @ **1,298 Ml/day**

Recycled Water Quality compliance for 2018: Sanitary (99%), Microbiological (97%) and Trace elements (97%)

Distribution:
Recycled water produced **822 Ml/day**, with 57.5% reused

Biosolids produced: **48,670** dry tonnes, 100% transferred to landfill sites for disposal.

5. Wastewater and Recycled Water

Licensees

Major Wastewater Licensees

In 2018, the DoE had three major wastewater licensees:

a. Abu Dhabi Sewerage Services Company (ADSSC) - licensed for collection, treatment and disposal of wastewater.
b. Al Etihad Biwater Wastewater Company (EB) - licensed for treatment of wastewater
c. Al Wathba Veolia Besix Wastewater Company (VeBes) – licensed for treatment of wastewater

Description of the assets and associated performance is discussed in subsequent sections of this report.

Recycled Water Distribution and Supply Licensees

In 2018, the DoE issued two recycled water distribution and supply licenses to ADDC and AADC.

The establishment of the recycled water sector came into effect on 1 January 2018, and the companies started developing this nascent business ,complying with its regulatory principles and managing its operations..

Small Scale Licensees

In recent years, the DoE has observed several companies are operating small scale sewerage systems throughout Abu Dhabi Emirate. DoE has obligated these companies to comply with the DoE's regulations by issuing licences to unlicensed facilities. Treatment capacities of these small-scale sewerage systems are 10,000 m3/day and below.

Wastewater Assets

Wastewater assets include collection, treatment and disposal assets.

Collection Systems

Wastewater collection is defined as the connection of premises to the sewerage system and the transportation of wastewater from premises or customers to the wastewater treatment system. The key components of the collection systems operated in the Emirate are:

- gravity sewers;
- pumping stations; and
- pumping mains.

In 2018 ADSSC operated 306 pumping stations which ranged in size from small local stations to large terminal pumping stations rated at over 300L/s.

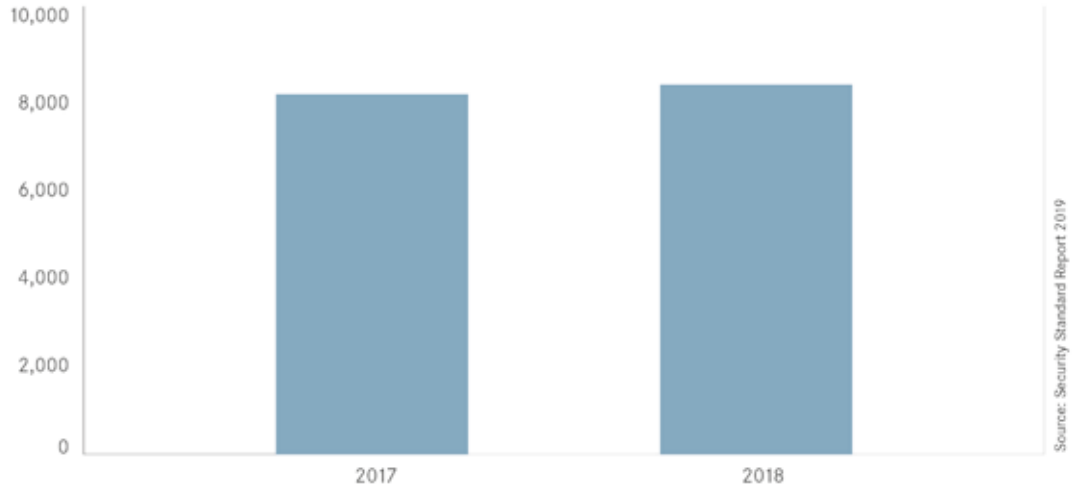
The Strategic Tunnel Enhancement Programme (STEP) became operational in 2018 receiving about 441,000 m3/day of raw sewage flow.

STEP is comprised of 45km of gravity link sewers, 41 km of gravity ‘main spine’ sewer tunnel, with a terminal pump station (PS01) lifting flows to Al Wathba ISTPs. Some of the benefits include allowing 35 existing pump stations to be decommissioned upon successful commissioning of PS01, with flows diverted into the STEP system upstream of these pump stations. Apart from freeing up valuable land, other benefits include reduced OPEX and improved service reliability.

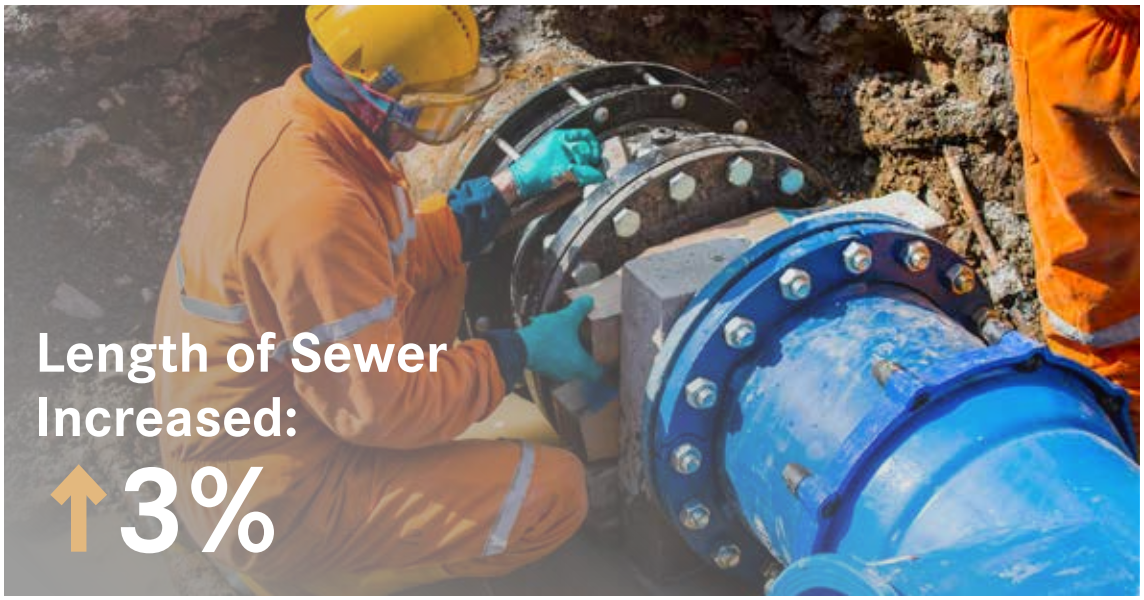
Currently, flows from catchments of main pumping stations in Abu Dhabi MPS1, MPS2, MPS3, MPS4, MPS13, MPS14, MPS6, MPS17, MPS8N and many smaller pumping stations are diverted to the STEP Tunnel through enhancement lines, link sewers and trunk lines . Several asset enhancement and link sewer projects are still underway for 2019 and the 2024 horizon..

Figure 33 illustrates the year on year change in the length of sewer network operated by ADSSC

Figure 33: Collection Network Length (km)



The length of sewer increased by 3% due to new network projects and networks adoption from developers.



Treatment and Disposal Assets

Wastewater treatment is defined as the reception of wastewater from the collection system, the treatment of wastewater and delivery of the resulting products to the disposal system.

Table 8 shows the total number of treatment plants operated by major licensees in 2018. In 2017, Masdar STP was decommissioned and Al Ghadeer STP was commissioned in 2018.

Table 8: Major Licensee Treatment Capacity

Major licensee treatment capacity	2017	2018
Sewage Treatments Plants (no.)	38	39
Total Installed Capacity (ML/day)	1,296	1,298

Table 9 illustrates the total annual flow handled by the major licensees between 2017 and 2018. In 2018 the treatment systems operated by major licensees managed an annual total flow of 311,858 Ml, a decrease of 2.69 %. This decrease was due to completing several wastewater networks rehabilitation projects by ADSSC, which resulted in reducing groundwater infiltration.

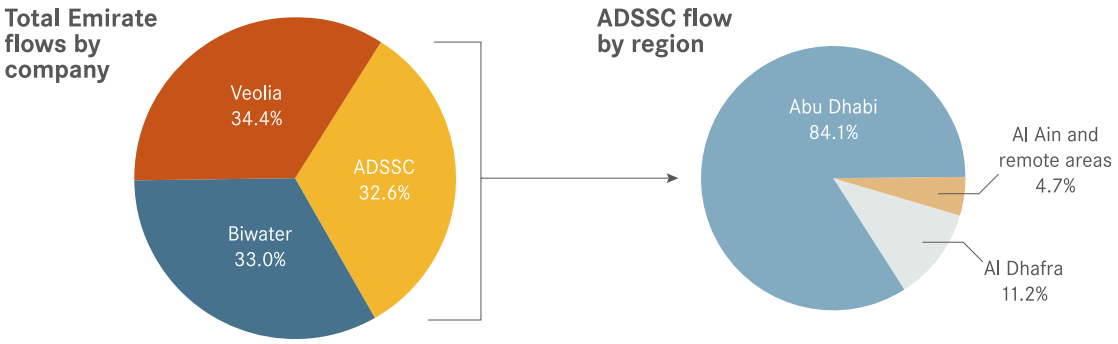
Table 9: Annual Flow (Ml)

2017	2018	% Change 2017 to 2018
320,475	311,858	-2.69%

Figure 34 illustrates the proportion of wastewater managed by each of the major licensees in 2018 and highlights the role played by Etihad Biwater and Veolia Besix who manage approximately 70% of the total wastewater treated in the Emirate.

The figure also illustrates the relative scale of ADSSC's treatment operations across its three regions. The treatment capacity in Abu Dhabi region makes up nearly 84% of the total with Mafraq STP remaining ADSSC's largest operational treatment works.

Figure 34: Proportion of Flow Handled by Major Licensees



Recycled Water Distribution and Supply Assets

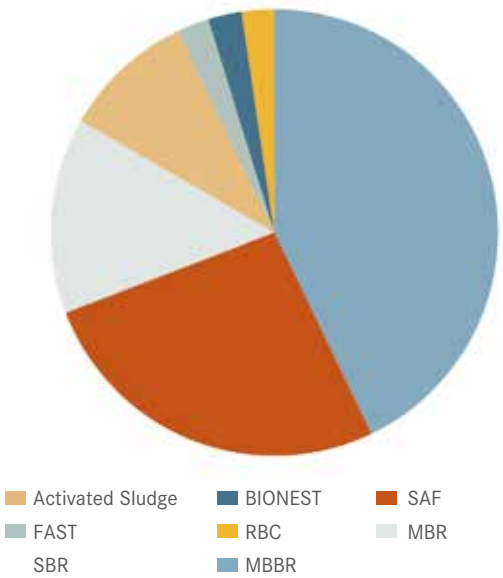
DoE issued Licenses to both ADDC/ADDC for the distribution and supply of recycled water effective 1 January 2018. Accordingly, the entire recycled water distribution and supply network is being transferred to the DISCOs from ADSSC and the municipalities. The DISCOs are currently carrying out projects to assess the asset condition of the transferred network.

Small Scale Licensees

In 2018 the DoE audited the small-scale sewerage systems to determine if the licensees are fulfilling their obligations with respect to licence conditions and applicable regulations and provide them with support and guidance on how to achieve compliance and to act against non-compliant licensees.

The sites audited had different biological treatment technologies and a statistical representation of the different treatment technologies being used on sites audited is provided in the chart below. Though this data does not provide a comprehensive process comparison or criteria for selection, this only provides a quantitative indication of the processes used.

Figure 35: STP Process



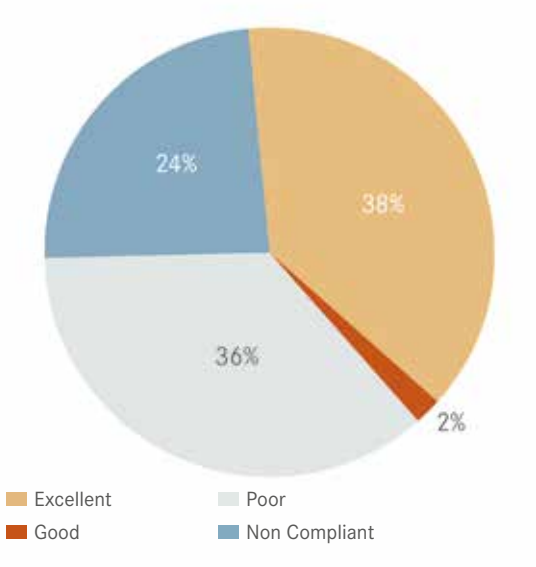
The performance of the STP was assessed by comparing the samples analysed as a part of the sampling program. The water from plants which complied with all water quality parameters were rated as excellent performers. The water from plants which met all the sanitary and microbiological parameters and did not meet the few trace elements were rated as good performers. The water from plants which failed on at least one of the sanitary parameters were rated as poor performers. The water from plants which failed most of the sanitary parameters or did not carry out any sampling and analysis were rated as non-compliant.

The impact of failure of the microbiological parameters is minor when all the sanitary parameters are fulfilled as this can be easily resolved by correcting the disinfectant dosage.

The result of the assessment and observations are as presented below.

Although none of the licensees provide recycled water quality to customers outside of their boundaries, the DoE has worked to improve compliance through organising education and awareness workshops with the licensees. Additionally, those licensees that do not provide demonstrable improvement in performance will be referred to the DoE's licensing and compliance department for further actions.

Figure 36: Recycled Water Quality Compliance & STP Performance



System Performance

This section reports on key performance measures for the collection, treatment, and disposal system operated by ADSSC.

The intention is to also report on the performance of the recycled water distribution and supply systems operated by AADC and ADDC

Collection Network Performance

Sewer Collapses per 100km

A sewer collapse is a break or collapse in any gravity sewer, pumping main or vacuum system main which forms part of the licensee's sewerage system and causes an interruption to the service.

The number of collapses per 100km of sewer is a good indicator of the effectiveness of collection system asset management activities and the performance of the operator in managing third party activities close to sewer systems.

Table 10 shows ADSSC's sewer collapse rate between 2014 and 2018 for each of ADSSC's operational regions. The 2018 data shows an increase in the collapse rate in all regions comparing to 2017.

Table 10: Sewer Collapses per 100km

Region	2014	2015	2016	2017	2018
Abu Dhabi	0.91	0.35	0.64	0.34	0.52
Al Ain	0.78	0.62	1.15	0.66	0.81
Al Dhafra	–	0.57	0.94	–	0.52
Emirate	**0.79**	**0.48**	**0.84**	**0.45**	**0.64**

Sewer Blockages per 100km

A sewer blockage is any partial or total blockage in any gravity sewer, pumping main or vacuum system main which forms part of the licensee's sewerage system and causes an interruption to the service.

The frequency of blockages per 100km is a good indicator of the effectiveness of operation and maintenance activities in the collection system.

The data presented in Table 11 reflects the blockage rate for the period 2014 to 2018 for ADSSC's sewers. The performance measure does not include data on the blockages cleared from private sewer systems which totalled a further 68,370 incidents in 2018.

Table 11: Sewer Blockages per 100km

Region	2014	2015	2016	2017	2018
Abu Dhabi	36.56	24.55	23.25	21.1	14.6
Al Ain	2.20	1.18	0.83	1.06	1.07
Al Dhafra	–	–	–	–	–
Emirate	**19.37**	**13.47**	**12.52**	**11.6**	**8.10**

The table illustrates that there has been a decrease in the reported blockage rate for Abu Dhabi region.

ADSSC report that blockages reflect the significant proportion of the network operating under surcharge conditions and its limited capacity to handle high flow conditions. ADSSC also report that fibre optic cables installed in the sewer system in Abu Dhabi City are proving to be a major cause of blockages.

There were no blockages reported on public sewer systems in the Al Dhafra Region.

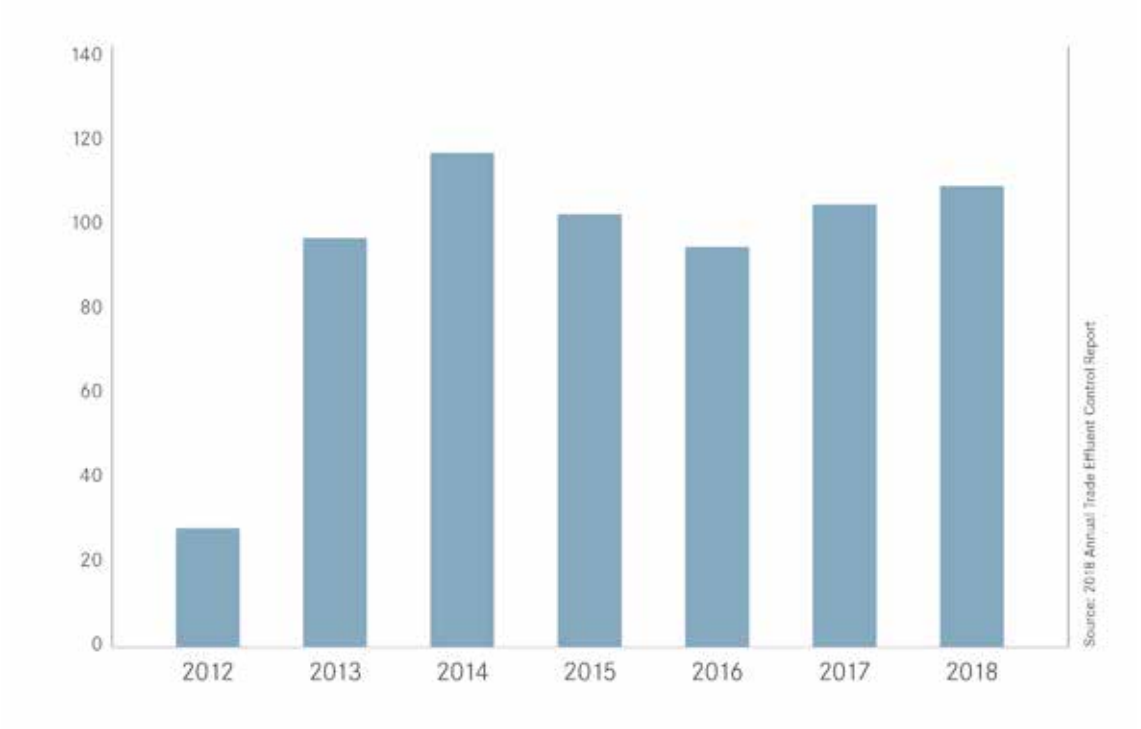
Quality Performance

Trade Effluent Control

The discharge of Trade Effluent poses a significant operational challenge to wastewater collection, treatment and disposal systems. In order to manage these risks, collection licensees are empowered to issue and enforce consents that define the terms and conditions under which the discharge can be made.

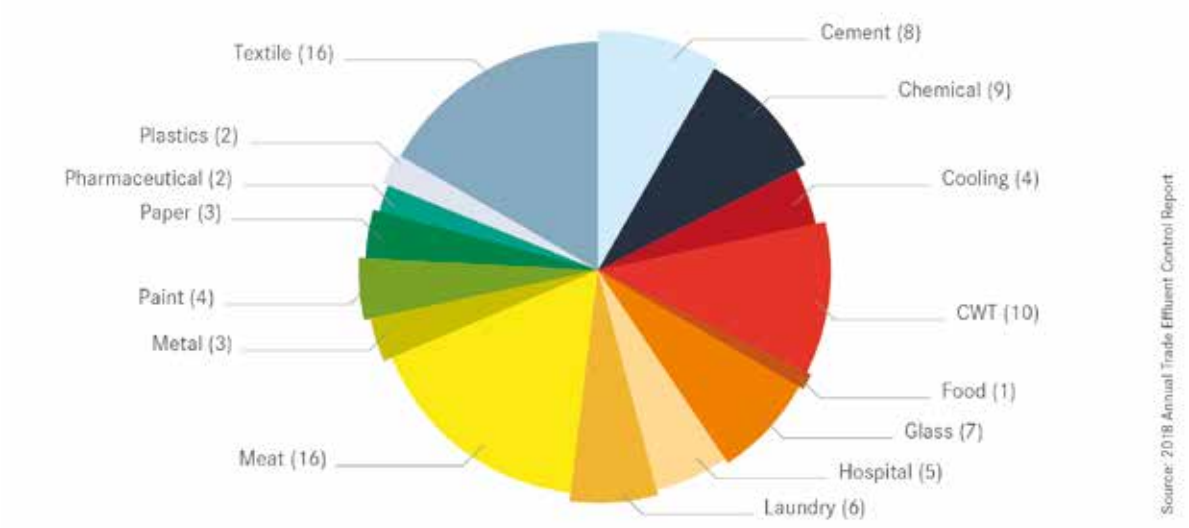
In 2018 ADSSC issued five new consents and terminated 12 other consents after investigations proved that the discharge was either domestic of nature or no longer connected to the sewer network. At the close of 2018 there were 110 consented entities and Figure 39 illustrates the change in number of consented entities between 2012 and 2018.

Figure 37: Number of Consented Entities



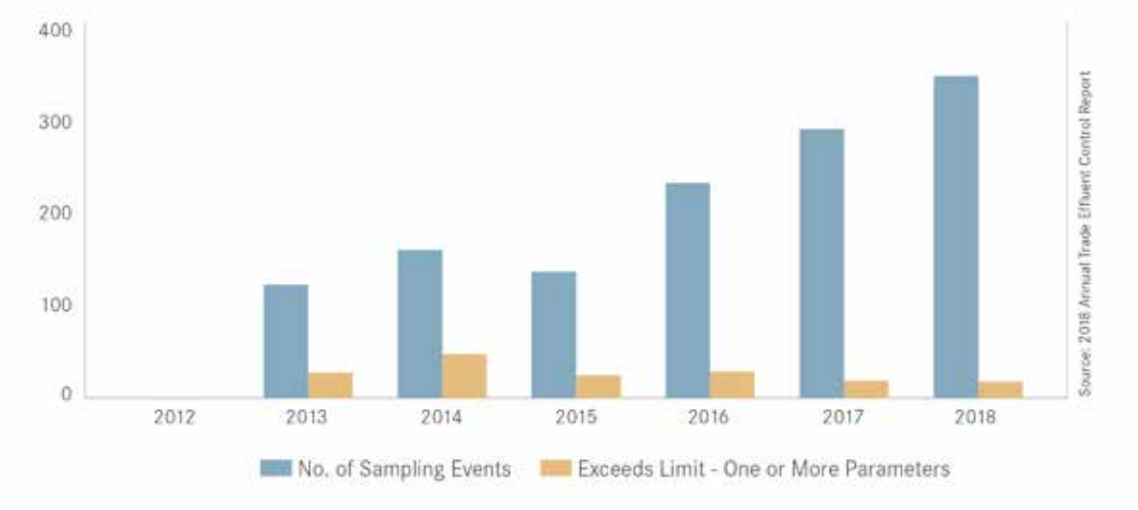
The largest contributors to the trade effluent flow were found to be the paperboard, metal finishing and food and beverage and water industries. A breakdown of consent holders by industry type is shown in Figure 38 below.

Figure 38 : Consent Holders by Industry Type



ADSSC categorises its consent holders as high, medium or low risk according to the size, nature of discharge, and consent holder performance history. This categorisation is used to define the sampling and inspection frequencies for each consent holder. Based on this ADSSC conducted 352 sampling and inspection assessments of consent holders in 2018. Figure 39 illustrates the increased number of sampling events since 2013 and the associated decrease in sampling exceedances over the same time period.

Figure 39: Number of Sampling Events



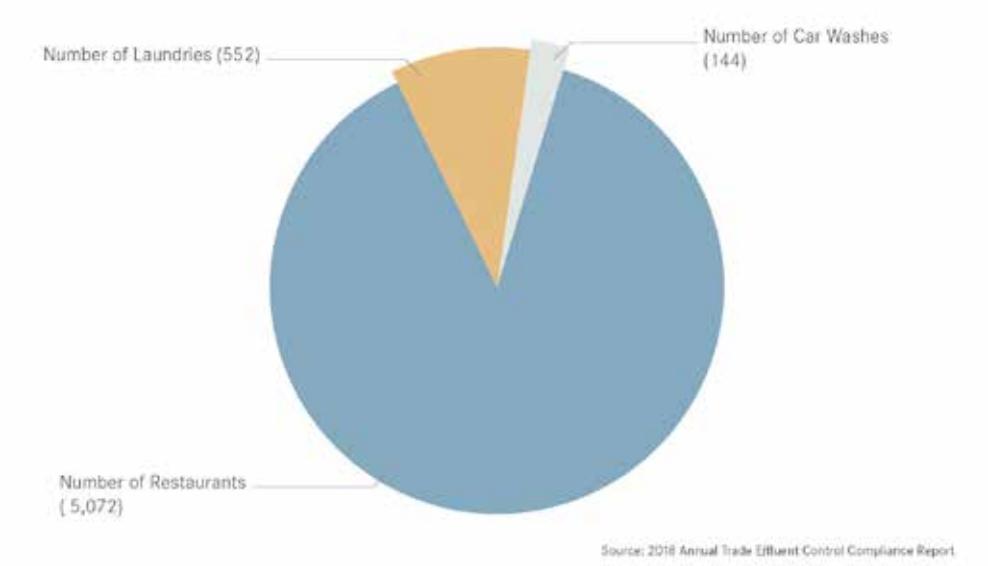
The most commonly exceeded parameters were COD, pH and TDS. These exceedances were related primarily to the slaughterhouses, large-scale laundries and metal products industries.

ADSSC issued 31 enforcement notices which required consent holders to address issues associated with sample failures or issues identified during inspections. Four of the enforcement actions were improvement notices.

The DoE recognises that the technical and financial effort involved with issuing and monitoring Trade Effluent consents for certain types of Trade Effluent is disproportionate to the risks posed to the receiving sewerage systems. Accordingly, these discharge types are designated as low-risk Trade Effluent and are managed by ADSSC through Codes of Practice.

There are currently three Codes of Practice in place covering restaurants and cafes, small-scale laundries, and vehicle washes. Figure 40 below shows breakdown of low-risk entities by type of business.

Figure 40: Breakdown of Low-Risk Entities by Type of Business

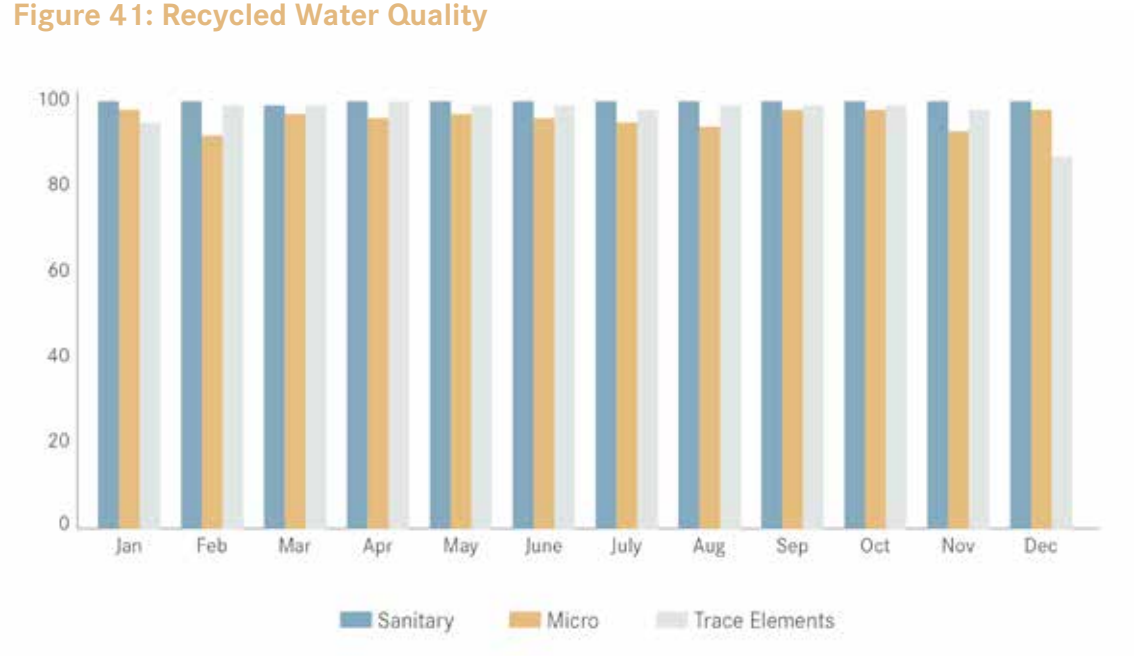


Quality of Recycled Water at the Disposal Point

The Recycled Water and Biosolids (RW&B) Regulations establish a legal framework for the safe and economic reuse and management of recycled water and biosolids throughout the Emirate. Developing relevant information on the quality of these important products and robust, transparent reporting will highlight compliance difficulties and allow licensees to develop effective operational or project-based solutions to drive year-on-year improvements.

Figure 41 below summarises the recycled water quality compliance for the five major treatment plants operated by large scale licensees in 2018 against the sanitary, microbiological and trace elements parameters outlined in the RW&B Regulations. These five treatment plants process more than 93% of the wastewater produced in the Emirate of Abu Dhabi. Compliance was assessed by establishing the proportion of samples that passed the relevant standards for the three key parameter groups.

Figure 41: Recycled Water Quality



The data shows excellent compliance throughout 2018 for sanitary and microbiological parameters, with occasional exceedances noted for some microbiological parameters. A temporary relaxation of the limits was granted to investigate treatment processes and review laboratory procedures and analytical techniques. Any trace elements related issues are followed up by ADSSC as part of their trade effluent control programme.

Additionally, it was note that salinity continues to be an issue in the raw wastewater entering the Abu Dhabi treatment facilities. This is caused primarily by groundwater infiltration entering the sewerage network through defective pipes, pipe joints, connections, or manholes. Asset enhancement schemes on Abu Dhabi Island have reduced the salinity entering Mafraq treatment plant. Similar schemes have been planned for Musaffah area to decrease the infiltration affecting Wathba 1 and Wathba 2 treatment plants.

Biosolids

Table (12) shows the amount of biosolids produced in 2017 and 2018.

Table 12: Biosolids Production

	2017	2018	% Change
Biosolids in tonnes dry solids	50,081	48,670	-2.8%

Only the five large treatment plants have treatment systems that can stabilise sewage sludge sufficiently for reuse as biosolids. All of the biosolids are currently being disposed to landfill subject to the regulation of the Environment Agency Abu Dhabi and the operation of The Centre of Waste Management - Tadweer. To divert the disposal away from landfill, ADSSC is actively seeking reuse outlets such as land application in forest preserves and potential industrial applications.

The total dry mass of biosolids produced in the Emirate in 2018 was 48,670 tonnes which was all transferred to landfill sites for disposal.

Quality of Recycled Water in Distribution System

The Executive Council Decision concerning the utilisation of recycled water assigned the responsibility of distributing the treated wastewater to ADDC and AADC and required distribution companies to develop a policy to manage the treated wastewater. The updated RW&B Regulations issued in 2018 also reflect these updated responsibilities requiring distribution companies to develop recycled water safety plans to the point of delivery to the end-users and to perform sampling at various zones throughout the Emirate of Abu Dhabi.

6. Health and Safety

Incident Reporting:

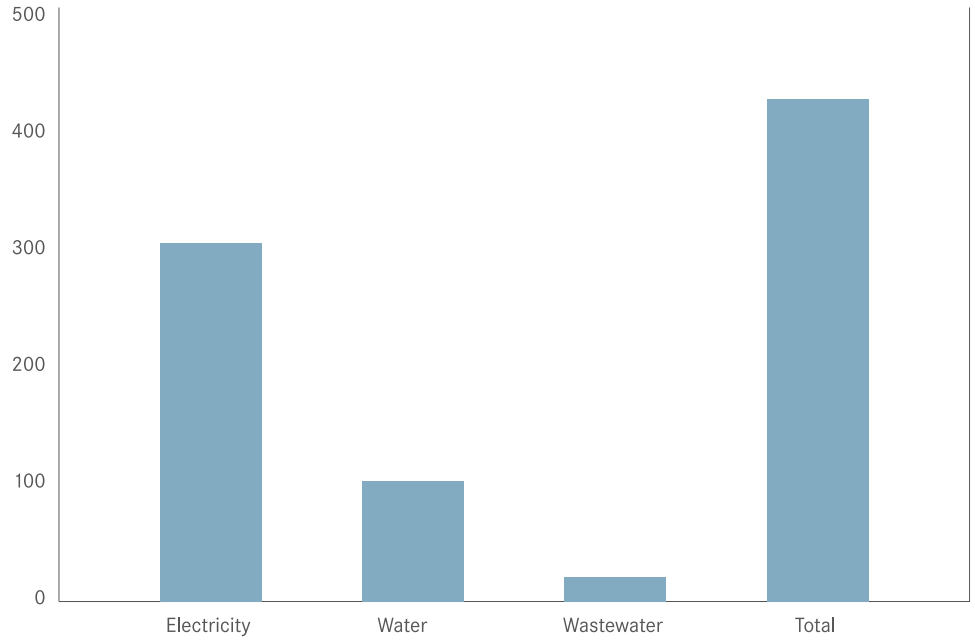
The DoE monitors HSE performance through a web-based incident reporting system. Incident reports are classified into three broad categories: operational, occupational health & safety, and environmental incidents.

Operational Incidents:

Operational incidents are defined as events that result in an interruption of service provided by the Licensee.

In 2018, the DoE received and processed 431 operational incident reports based on **Incident Reporting regulation;** 25 of them are under the 5 hours reporting category and considered critical.

Figure 42: Type of Incidents 2018



Operational Power Incidents:

The 7 most critical operational power related incidents fell into two specific categories:

- An interruption on any 33kV, 22kV and 11kV bus bar section at any grid station (220/33, 132/33, 132/22, 132/11kV)
- Total Plant trip (Electricity)

The main causes of the three interruption incidents were found to be flashover on 33 KV bus bar, flashover in cable compartment, and cable joint failure. Each of the total plant trips had a unique root cause, namely: equipment malfunction, Inadvertent Disturbance, welding failure and loss of instrument air supply.

Operational Potable Water Incidents

The total percentage of incidents that occurred in 2018 was 6.48%, 1.85% and 91.67% respectively in the production, transmission and distribution networks.

The majority of the incidents that occurred in the thermal plants were due to operational, mechanical, and process issues. Those trips did not affect the water quality or the security of supply.

Operational Wastewater Incidents

The operational wastewater related incidents predominantly were classified under the category ‘A failure of a disposal system that prevents delivery of recycled water or biosolids supply to a customer for more than 24 hours or by more than 50% of the agreed volume or mass’. The main causes for the incidents were found to be pipe age, and leaks from pipe joints due to ground settlement.

In all cases no disruption was caused to the public and there was only one incident that resulted in a discharge of partially treated wastewater to the environment (covered in further detail in environmental incidents section below). Additionally, a review of the incidents showed that the supply was disrupted for less than 24 hours and less than 50% of the agreed volume. Due to this, the classification and reporting of such incidents has been reviewed for the 2019 Incident Reporting Regulations update.

H&S Incidents

Health & Safety incidents include:

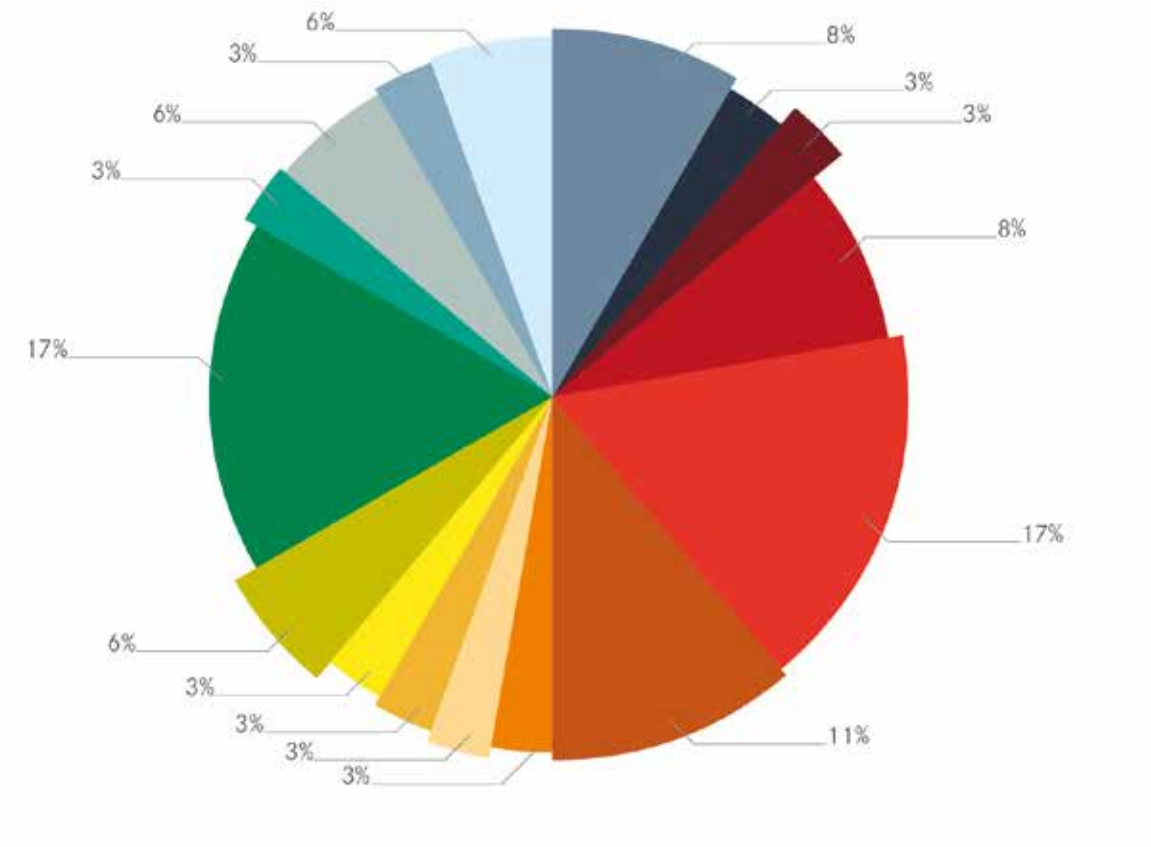
- **Work-Related Fatality** which is a death resulting from a work related injury or illness, regardless of the time intervening between injury and death.
- **Lost Time Injury** which is any absence from work resulting from work-related Fatalities, Permanent Total Disabilities, Permanent Partial Disabilities and Lost Workday Cases.
- **Lost Time Injury Frequency Rate (LTIFR):** The total number of Lost Time Injuries per million hours worked during the period. Calculation: No. of LTI's x 1,000,000 / Working Hours
- **Lost Time Injury Severity Rate (LTISR):** The total number of lost work days per million hours of working. Calculation: No. of Work Days Lost x 1,000,000 / Working Hours

In case of Death (Fatality) or Permanent Total Disability, no Lost Workday shall be recorded.

HSE Incidents Root Causes

The root cause of the majority of HSE incidents are related to the OHS Management System Factor.

Figure 43 : Type of Incidents 2018



Factor	Category	Number of Incidents
Personal Factors	Behaviour	3
	Mental State	1
	Physical Capability	1
	Physical Condition	3
	Unsafe Act	6
System Factors	Inadequate Contractor Management	4
	Inadequate Engineering or Design or Controls	1
	Inadequate Leadership Supervision	1
	Inadequate Maintenance	1
	Inadequate Risk Assessment or Management	1
	Operation Factors	2
	Operational Factors	6
	Protective Methods	1
	Training & Competency	2
	Work Rules or Policies or Standards or	1
Work Place	Work Place Condition	2

Environmental Incidents

Events resulting in an unplanned or uncontrolled release of a product or chemical with negative impact to the environment – water, air, soil, animals, plants, ecology and social life are classified as Environmental Incidents.

7. Environment

DoE ensures that environmental protection is a priority in all operations within the energy sector. A dedicated team is assigned to oversee the environmental performance in the sector as well as to ensure all operations are aligned with the Emirate's legal requirements.

Environmental Performance

DoE monitors the environmental performance of all licensees on a quarterly basis. The licensees submit an environmental report summarising the data collected in regards to air quality emissions, sea water inlet and outfall discharge, and the waste register throughout the reporting period.

DoE works closely with the Environment Agency- Abu Dhabi to ensure compliance with all regulations and agreed protocols for the energy sector. Also, the DoE is a part of the consultation process for all environmental matters related to the energy sector through participating in working committees and groups, and reviewing environmental regulations and guidelines.

8. Acknowledgment

Abu Dhabi Department of Energy (DoE) has prepared this 2018 Technical Report in collaboration with Abu Dhabi energy sector's stakeholders. DoE extends its gratitude and appreciation to all participating entities for their cooperation, transparency and integrity in submitting the required reports and data as per the applicable regulations.

Participating Entities:

- Al Etihad Biwater Wastewater Company (EB)
- Al Wathba Veolia Besix Wastewater Company (VeBes)
- AADC
- ADDC
- ADSSC
- AMPC
- APC
- ECPC
- EWEC
- FAPCO
- GTTPC
- MIPCO
- RPC
- SAPCO
- SCIPCO
- SEMBCORP
- SHAMS
- TAPCO
- TRANSCO

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DEPARTMENT OF ENERGY

2019
ANNUAL TECHNICAL REPORT

For Water, Wastewater and Electricity Sector
in the Emirate of Abu Dhabi