QATAR WATER CHALLENGES

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April 2012
Qatar population growth rate against years

0.744 M in 2000 to 1.7 M in 2010 → 2.28 times increase in 10 years
<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>1908 est.</td>
<td>22,000</td>
</tr>
<tr>
<td>1939 est.</td>
<td>28,000</td>
</tr>
<tr>
<td>Late 1960s</td>
<td>70,000</td>
</tr>
<tr>
<td>1986</td>
<td>369,079</td>
</tr>
<tr>
<td>1997</td>
<td>522,023</td>
</tr>
<tr>
<td>2000</td>
<td>744,483</td>
</tr>
<tr>
<td>2001</td>
<td>769,152</td>
</tr>
<tr>
<td>2002</td>
<td>793,341</td>
</tr>
<tr>
<td>2003</td>
<td>817,052</td>
</tr>
<tr>
<td>2004</td>
<td>840,290</td>
</tr>
<tr>
<td>2005</td>
<td>863,051</td>
</tr>
<tr>
<td>2006</td>
<td>885,359</td>
</tr>
<tr>
<td>2007</td>
<td>1,207,229</td>
</tr>
<tr>
<td>2008</td>
<td>1,524,789</td>
</tr>
<tr>
<td>2009</td>
<td>1,309,000</td>
</tr>
<tr>
<td>2010</td>
<td>1,696,563</td>
</tr>
<tr>
<td>2011</td>
<td>1,692,262</td>
</tr>
</tbody>
</table>
Main Water Resources
1. Rain Fall

Qatar Has Low Rainfall Averaging 82mm Annually, 1990-2008
1- Northern GW (NGW) basin
Salinity (S) 500 - 3000 ppm and up to 10 000 ppm near coasts by SW,
covers ≈ 19% of Qatar at 10 - 40m water depth ground

2- Southern GW (SGW) Basins, S (3,000-6,000 ppm)
Cover ½ Qatar land, not suitable for agriculture

3- Three secondary basins called:
   Abu Samra, depth 22 - 80 m below ground
   Doha and Aruma deep GW basins SW of country, S ≈ 4 000 ppm, at deep depths of 450-650 m
Groundwater GW

- GW average recharge/y from rainfall $\approx 55.9$ Mm$^3$/y.
- GW inflow of GW from SA $\approx 2.2$ Mm$^3$/y,
- Total renewable GW $\approx 58.1$ Mm$^3$/year for the period 1972-2005.
- GW extraction from NGW and SGW $\approx 220.2$ Mm$^3$ in 2004-2005
- Water abstraction many times natural GW recharge rate.
- Continued over-exploitation of fossil GW reserves threatens the remaining reserves from saltwater intrusion, while overuse of GW for agriculture is resulting in soil salinization and desertification.
Number of wells and water abstraction in Qatar

Source of data: Amer and Abdul-Wahab, 2009, derived from the Agricultural and Aquatic Research Department, Ministry of Municipality and Urban Planning

Notice the decline of GW output since 2002
3. Wastewater

- All population have clean drinking water access.
- 68% of all Qatar’s buildings are connected to the sewage network (95% of Doha buildings connected).
- One-third of municipal (WW) wastewater is treated and recycled.
- Balance is lost as leakage or from buildings not connected to the sewer system.
- Most of supplied water has potable quality, misused in services that do not need high quality, e.g. garden irrigation, car washing, toilet flushing, and others.
Treated Waste Water Capacity

• Treated effluent from the two main (TWW) plants in Doha ≈140,000 and 150,000 m³/day in 2005.
• The two main sewage TWW use tertiary treatment (96% of TWW influent)
• The known TWW plants and their capacities in (m³/d) are:
  • Doha West known as Sailiyyah (135,000),
  • Doha South known as Nuaija (112,000),
  • Doha North known as Lusil (60,000),
  • Doha Industrial area (12,000), Al-Khor (4,860), and
  • Al Thakhira known as Dakheri (30,000).
• So, TWW total capacity ≈ 354,000 m³/d.
• Another WWT plant of 28,700 m³/d capacity started to be built in 2009 at the site of the new airport for its landscape irrigation.
• Total WWT plants is expected to increase to 129.4 Mm³/y.
Use of Treated Waste Water in 2005

Use of Treated Wastewater, Qatar, 2005

- El-Rakeya Farm: 53%
- Doha: 17%
- El-Refaa Farm: 10%
- Disposal: 20%

Source of data: Amer and Abdel-Wahab, 2009
4. Desalted seawater DW

- DWQatar’s first plant in 1953, and had 680 m$^3$/d
- More plants were added later, and capacity now 1.49 Mm$^3$/d in 2011
- Large capacity DP combined with GT and GTCC Power Plants (PP),
- Called Cogeneration Power Desalting plants (CPDP).
- Next table gives names and capacity of DP
Total Water Production from 2006-2010

Water Production, Million Cubic Meters

<table>
<thead>
<tr>
<th>Year</th>
<th>Water Production, MM3</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>225.1</td>
</tr>
<tr>
<td>2007</td>
<td>251.2</td>
</tr>
<tr>
<td>2008</td>
<td>312.4</td>
</tr>
<tr>
<td>2009</td>
<td>341.0</td>
</tr>
<tr>
<td>2010</td>
<td>373.6</td>
</tr>
</tbody>
</table>
# Desalination Plant in Qatar

<table>
<thead>
<tr>
<th>Desalination Plant</th>
<th>Power plant capacity, MW</th>
<th>Total Capacity, m³/d</th>
<th>Total capacity, (MIGD)</th>
<th>Starting date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ras Abu Aboud</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ras Abu Fontas A</td>
<td>497</td>
<td>318,226</td>
<td>70</td>
<td>1980</td>
</tr>
<tr>
<td>Ras Abu Fontas B</td>
<td>609</td>
<td>150,000</td>
<td>33</td>
<td>1995</td>
</tr>
<tr>
<td>Ras Abu Fontas B1</td>
<td>377</td>
<td>240,000</td>
<td>53</td>
<td>2002</td>
</tr>
<tr>
<td>Ras Abu Fontas B2</td>
<td>567</td>
<td>136,000</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Ras Laffan A</td>
<td>756</td>
<td>181,843</td>
<td>40</td>
<td>2003</td>
</tr>
<tr>
<td>Ras Laffan B</td>
<td>1025</td>
<td>272760</td>
<td>60</td>
<td>2006</td>
</tr>
<tr>
<td>Meisieed</td>
<td>2007</td>
<td></td>
<td></td>
<td>2009</td>
</tr>
<tr>
<td>Ras Girtas</td>
<td>2730</td>
<td>286,400</td>
<td>63</td>
<td>2010</td>
</tr>
<tr>
<td>Satelites</td>
<td>184</td>
<td></td>
<td></td>
<td>1983</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8752</strong></td>
<td><strong>1,450,229,349</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Production of desalinated water has increased massively but has barely kept pace with population growth.
Desalination energy Consumption & CO$_2$ emission

- In 2010, produced EP = 28144 GWh and of DW = 373 Mm$^3$ (1.022 Mm$^3$/d).
- Consumed fuel energy and its CO$_2$ emission are calculated here.
- Equivalent consumed EP per m$^3$ of DW by MSF $\approx$ 20-kWh/m$^3$.
- Consumed equivalent EP to desalt 1.022 Mm$^3$/d = 20.44 GWh/d, and 7461 GWh/y.
- Total equivalent EP output for electricity and DW (28144 + 7461) = 35605 GWh.
- DW share of 21%.
- For 35% average efficiency, consumed fuel energy = 366.3 MGJ.
  (equivalent to 61.03 Mbbl, or 348.9 BCF of NG.
- Qatar produced NG in 2009 3154 BCF of NG in 2009, while consumed 745 BCF.
- CPDP consumed NG about 11% of total produced NG in 2009, and about 40% of total NG consumption.
• NG burned in CPDP = 366.2 BCF = = 7.602 M ton, 1.6 Mton by DW.
• CO₂ emission due to burning 7.602 M ton of NG is 20.922 M tons.
• DW contributed 11.23 kg/m³ CO₂.
• In brief, desalting 373 Mm³ in 2010 (1.02 Mm³/d) causes burning 1.6 tons of NG and the emission of 4.4 million tons of CO2.
• Choice of SWRO to can save 75% of fuel used, reduce CO₂ emission.
• Average SWRO consumed energy with energy recovery devices is 5 kWh/m³.
• Produced DW increased from 178 Mm³/y in 2004 to 373 Mm³/y in 2010, significant annual increase of 14%.
Arrangement of GT combined cycle (GTCC) with BPST

Gas Turbine Generators
3 × 215.5 MW

Steam Turbine Generator
1 × 215.7 MW

HEAT RECOVERY STEAM GENERATOR

DESALINATION PLANTS
3 HP EJECTORS
3 × 15 MIGD MSF UNITS
Arrangement of BPST supplying steam to 3 MSF
Steam Turbine Generator
## Water Storage Capacity in Qatar - 2007

<table>
<thead>
<tr>
<th>Storage Facility</th>
<th>Storage Capacity (m³)</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reservoir</td>
<td>1,927,542*</td>
<td>97.2</td>
</tr>
<tr>
<td>Ground Tank</td>
<td>25,167</td>
<td>1.3</td>
</tr>
<tr>
<td>Elevated Tank</td>
<td>2,987</td>
<td>0.1</td>
</tr>
<tr>
<td>Water Tower</td>
<td>27,640</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>1,983,336</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

* Excludes non-operating reservoir under refurbishment or maintenance

Source: KAHRAMAA, 2008
Water Use and Consumption
### Water Consumption and Government Subsidy in Qatar, 2003

<table>
<thead>
<tr>
<th>Sector</th>
<th>Subsidy Per Unit (QR per m³)</th>
<th>Total Consumption (million m³)</th>
<th>Total Subsidy (QR million)</th>
<th>Percentage Distribution of Subsidy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential (Qatari)</td>
<td>10</td>
<td>52.3</td>
<td>524</td>
<td>63</td>
</tr>
<tr>
<td>Residential (non-Qatari)</td>
<td>5.6</td>
<td>24.6</td>
<td>138</td>
<td>17</td>
</tr>
<tr>
<td>Commercial</td>
<td>5.6</td>
<td>10</td>
<td>56</td>
<td>7</td>
</tr>
<tr>
<td>Government</td>
<td>10</td>
<td>3.6</td>
<td>36</td>
<td>4</td>
</tr>
<tr>
<td>Industrial</td>
<td>5.6</td>
<td>13.4</td>
<td>75</td>
<td>9</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>8.0</strong></td>
<td><strong>103.9</strong></td>
<td><strong>829</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

*Note: Figures are independently rounded*

*Source: Al Mohannadi, 2009*
Use of Water in Qatar-2009

Households in Qatar Use Water Mainly for Personal Hygiene

- **Bathing**: 43%
- **Personal washing**: 21%
- **Toilet**: 11%
- **Dish washing**: 10%
- **Garden watering**: 5%
- **Clothes washing**: 3%
- **Floor cleaning**: 3%
- **Car washing**: 2%
- **Cooking and drinking**: 2%

Source of data: Al-Mohannadi, 2009
Water withdrawal by source
Total: 0.444 km³ in 2005

- Reused treated wastewater: 10%
- Desalinated water: 41%
- Groundwater: 49%
### Water withdrawal by sector

Total: 0.444 km$^3$ in 2005

- **Municipalities**: 39%
- **Irrigation + Livestock**: 59%
- **Industry**: 2%

### Water withdrawals by different sectors in Qatar (2005)

<table>
<thead>
<tr>
<th></th>
<th>Agriculture</th>
<th>Domestic</th>
<th>Industry</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>million m$^3$/year</td>
<td>%</td>
<td>million m$^3$/year</td>
<td>%</td>
</tr>
<tr>
<td>Groundwater</td>
<td>218.3</td>
<td>83.5</td>
<td>2.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Treated sewage water</td>
<td>43.2</td>
<td>16.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Desalinated water</td>
<td>-</td>
<td>-</td>
<td>171.8</td>
<td>98.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>261.5</td>
<td>100.0</td>
<td>174.2</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>% by sector</strong></td>
<td>58.9</td>
<td>-</td>
<td>39.2</td>
<td>-</td>
</tr>
</tbody>
</table>
The picture should have been changed in 2010, as DW becomes 373 Mm³/y (compared to 180 Mm³/y in 2005 or 207% increase in 5 years).

Similarly TWW was increased from 43.3 Mm³/y in 2005 to 129.4 Mm³/y in 2009, almost 300%.

If the GW is limited to 200 Mm³/y, then the total water withdrawal is 702.4 Mm³/y.

The percentage water withdrawals in 2010 can be about 53.1% for DW, 18% for TWW, and 27.9% for GW.
About a third of water produced leaks into the water table each year.

**Desalination**
- 312 million cubic metres

**Municipal use**
- ~200 million cubic metres

**Small Industry waste water**
- ~18 million cubic metres

**Sewage network**
- ~96 million cubic metres
  - Disconnected homes dump untreated sewage: ~75 million cubic metres
  - Excess treated sewage effluent: ~70 million cubic metres

**Water table**
- ~120 million cubic metres

**Leakage in transmission**
- ~100 million cubic metres

**Leakage of untreated sewage in transmission**
- ~20 million cubic metres

**Outflows pumped to sea**
- Untreated septic lagoons: ~95 million cubic metres
  - Treated septic lagoons: ~70 million cubic metres
  - Fodder: ~25 million cubic metres
  - Irrigation: ~1 million cubic metres
  - Runoff: ~0.5 million cubic metres
  - Septic tank overflow

**Runoff**
The sustainability of water in Qatar is at risk, where the extracted GW is several times its replenishments rate.

1- The rate of consumed renewable resource should be less than its replenishment rate. The municipal water supply depends almost completely on DW. The used desalting process is energy-intensive, and costly. The fuel consumed, NG, is finite and non-renewable.

2- The rate of consumed non-renewable resource (NG here) should be less than the rate of developing another alternative; and no alternative here. Burning fuel to produce DW emits gases, which pollutes the air, contributes to the greenhouse gases (GHG) causing climate change.

3- Polluting gases should be treated to render them unharmed to the environment; which is not the case here. The use of TWW is limited to some agriculture and landscaping, and at low rate compared to potable water consumption (about 25%). The WW is a water resource after being reclaimed, while most of it is wasted here.
Some measures to be considered:

- Most WW in Qatar is treated to the tertiary level and is used for irrigation. The dissolved organics and other contaminants limit full utilization of this valuable resource. The Quaternary treatment is producing potable water quality to meet unrestricted residential uses and industrial applications requiring ultra-pure water. Membranes of different pore sizes are usually used in this process such as micro-filtration (MF), ultrafiltration (UF), nano-filtration (NF), and hyper-filtration reverse osmosis (RO) in descending pore diameter order. The quaternary treated are used as direct potable water or recharged to aquifers for storage and then extracted for potable purposes in many parts of the world.
Continue Some measures to be considered:

- Increasing natural recharge of aquifer by drilling of wells (with a special design including a perforated casing and graded gravels) in depressions to recharge water from occasional storm through the wells to depths that reach the water bearing formations to accelerate the natural recharge of floodwater.

- Decrease the losses between municipal water supply and the treated waste water (TWW), which represents only 25% of the municipal water supply, and should be at least 60%.

- Expanding the use of Dual distribution system, one for potable quality water for drinking and cooking, and one for less quality for landscaping, toilet flushing, etc.
Thank You

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