Residential Water Consumption in Saudi Arabia

Loyola Marymount University
SELP – 695 Integrative Project
Instructor: Dr. Karen Miller
Student: Abdulaziz Sulaimani
Fall 2015
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History

- Saudi Arabia is one of the biggest countries in Middle East and a desert country without any stable rivers or lakes.

- Sources of water in Saudi Arabia are Groundwater and Desalination Plants.

- The population in Saudi Arabia is 30 million.

- The average water consumption per capita is 386 liters/day, which is very high comparing to the global average.

- The average rainfall in Saudi Arabia is an estimated 3 inches/year.
Summary of Current Problem

1. Water quality and pollution
2. Drilling for groundwater without legal permit
3. Using the wrong irrigation method
4. Increased water demand due to population growth
Problem Statement

- With the high increase of population in Saudi Arabia, as well as the hot and dry weather around the year, the people need water to live.

- Consumption of water in Saudi Arabia is 91 percent more than the global average.

- About six times more than used in UK

- Demand for water by household in Saudi Arabia is growing at the rate of 7.5 percent annually.
Water consumption in households

Water consumption average in Saudi per capita is 386 liters/day, categorized as the following:

- Kitchen (11 Liters)
- Laundry (38 Liters)
- Shower & Bath (76 liters)
- Faucets (11 Liters)
- Toilet (95 Liters)
- Other like gardening, car wash, and swimming pool (144 Liters)
Project objective

- The major objective:
  - To reduce water consumption by residents in Saudi Arabia.

- There are many benefits in reducing water consumption.

- Ensure and reserve enough water for coming generations.

- The goals are:
  - Accurately measure residential water consumption numbers.
  - Raise awareness of the importance of water consumption.
  - Provide National Water Company with several choices and alternatives to control water usage.
  - Analyze the proposed alternative approach in order to clarify its reliability and validity.
System Identification/Characterization

What is in the system?
- Water usage, citizens, bathroom, kitchen, National Water Company, Ministry of Water & Electricity

What is outside of your system?
- Water availability, houses, maintenance

What are the internal processes?
- Faucets, bath tub, shower, laundry, car wash, irrigation, toilet

What are the products?
- Lower water consumption
System Identification/Characterization

Who is the customer for the system?
- National Water Company

Who is the supplier for the system?
- Ministry of Water & Electricity

What is the next bigger system containing your system?
- Industry and agriculture consumption

How does this system satisfy a mission or capability need?
- By reducing water consumption in residential areas
Top Level Requirements

1. The system shall reduce water consumption in Saudi Arabia by 16 – 40%.

2. The system shall be capable of determining leaks in the water pipes network.

3. The system shall apply to new homes and existing homes.

4. The system shall meet the specifications and standards for the water provider.

5. The system shall provide accurate usage reports for water users.
Stakeholders

➢ Ministry of Water & Electricity (MoWE): controls the water provider and provides them with resources

➢ National Water Company (NWC): the provider of water in Saudi Arabia

➢ Residential aspect: people who live in Saudi Arabia
Alternative Solutions

My choice of alternative is based on a survey I did in Saudi Arabia:

A1. Education for water consumption
A2. Greywater system
A3. Limitation of water usage
Education for Water Consumption (A1)

Education methods:
1) TV advertisements
2) Text reminders in high season
3) Flyers
<table>
<thead>
<tr>
<th>Location</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bathroom</td>
<td>• Do not leave the tap open while brushing your teeth, shaving, and washing your hair.</td>
</tr>
<tr>
<td></td>
<td>• Reduce the size of toilet tank. (add milk gallon filled by sand).</td>
</tr>
<tr>
<td></td>
<td>• Use new toilet with sensor for control water flushing</td>
</tr>
<tr>
<td>Kitchen</td>
<td>• Wash fruits and vegetables in bowl instead of leaving the water running.</td>
</tr>
<tr>
<td></td>
<td>• Do not use water for defrosting frozen foods, but use microwave.</td>
</tr>
<tr>
<td></td>
<td>• Scrape dishes rather than rinse before putting them in the dishwasher machine.</td>
</tr>
<tr>
<td></td>
<td>• Use the dishwasher machine when its at full capacity.</td>
</tr>
<tr>
<td>Household garden</td>
<td>• Use Appropriate Plants (Xeriscape)</td>
</tr>
<tr>
<td></td>
<td>• Cover the soil's surface around plants with a mulch (wood chips)</td>
</tr>
</tbody>
</table>
Education for Water Consumption (A1)

- Educate people and reduce water consumption:
  1. Explain the current situation and the future.
  2. Explain about water conservation and how important it is.
  3. Motivate people to understand the problem of high water consumption average per capita and the low price compared to other countries.
  4. Teach people how to use free water flow tools.
Graywater system (A2)

Greywater is water that has been used for washing dishes, laundry, kitchen, and bath.
Categories of Greywater system

Greywater

- Low-filtration
  - Shower
  - Bathroom Faucets
- High-filtration
  - Kitchen
  - Laundry
Uses of Graywater (A2)

- Garden watering
- Toilet flushing
- Laundry, but only without liquid fabric softener
Benefits of Greywater (A2)

- The main benefit of greywater is to reduce the amount of fresh water consumption as well as sewage.
- Recycling of graywater could cut residential water use by 16 - 40% depending on house size.
- Reduce water bills.
- Connect homeowners to their water supply.
Greywater system (A2)

- The National Water Company will be the main provider of the system.
- The home equipment will be charged in the water bills by an affordable amount monthly.
- The graywater system will be required for all new homes and apartment buildings.

<table>
<thead>
<tr>
<th>Total Cost</th>
<th>Per month</th>
<th>Per year</th>
<th>In 20 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3000 - $4600</td>
<td>$20</td>
<td>$240</td>
<td>$4800</td>
</tr>
</tbody>
</table>

Greywater Payment Cost
Limitation of water usage (A3)

- The main reason to issue a limit code for water usage is because water is very cheap and people need an incentive.
- The cost of water per 100 liters in Saudi Arabia is 1.6$, but the resident pays only 0.026$.

<table>
<thead>
<tr>
<th>Pricing Tier</th>
<th>Consumption (liters/day)</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>Up to 100</td>
<td>$0.026</td>
</tr>
<tr>
<td>Tier 2</td>
<td>101-200</td>
<td>$0.052</td>
</tr>
<tr>
<td>Tier 3</td>
<td>201+</td>
<td>$0.078</td>
</tr>
</tbody>
</table>
Proposed Alternative Approach
Greywater system

- Due to the lack of quantitative data regarding residential water consumption in Saudi Arabia, I did a survey.
- A total number of 113 people took the survey, 74 men and 39 women from different age groups.
  - Education for water consumption (27%)
  - Greywater system (44%)
  - Limitation of water usage (29%)
4. How many people live in your household?
- [ ] More than 10 people
- [ ] 5-10 people
- [ ] Less than 5 people
- [ ] 5 or less
- [X] You only

5. Put the following solutions in order from 1-3 (1 is the most important).
- [ ] Educate people for water consumption
- [ ] Limitation of water usage
- [ ] Use graywater system

6. Would you use a solution to minimize water consumption if it was available?
- [ ] Yes
- [ ] Most likely, yes
- [ ] Probably
- [ ] No

7. Of the choices below, which do you think would encourage people to minimize their water consumption?
- [ ] Increasing water price
- [ ] Control in water availability
- [ ] Tariff for extra consumption

8. What is your gender and age group?
- [ ] Male
- [ ] Female

Thank you very much for taking the time to complete this survey.
System Architecture for Greywater

NWC
Installment equipment

KSA Citizens
Consume low water

MoWE
Provide equipment

OV-1 Operational View
System Architecture

OV-2 Operational Resources Flow Description

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>World</th>
</tr>
</thead>
<tbody>
<tr>
<td>MoWE</td>
<td>Ministry of Water and Electricity</td>
</tr>
<tr>
<td>NWC</td>
<td>National Water Company</td>
</tr>
</tbody>
</table>
## System Architecture

<table>
<thead>
<tr>
<th>NO.</th>
<th>Source</th>
<th>Destination</th>
<th>Relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MoWE</td>
<td>NWC</td>
<td>Asking for equipment codes, how many have been installed</td>
</tr>
<tr>
<td>2</td>
<td>NWC</td>
<td>MoWE</td>
<td>Provide chart of homes who received equipment, and report how many liters have been saved and consumed.</td>
</tr>
<tr>
<td>3</td>
<td>NWC</td>
<td>KSA Citizens</td>
<td>Install the equipment and create installation fee</td>
</tr>
<tr>
<td>4</td>
<td>KSA Citizens</td>
<td>NWC</td>
<td>Paying the bill, consume low water, and answer any survey that comes from NWC.</td>
</tr>
</tbody>
</table>
System Architecture

Ministry of Water & Electricity

National Water Company

Greywater system  Bills  Inspectors for water leak

KSA citizens

OV-4 Organization relationship chart
Ethical issues

- People pay water bills and assume they own it.
- Wealthy families consume more water than average people.
- The rich are less sensitive to the price. From July 2014 till September a person in Compton used only 63.6 gallons while a person from Beverly Hills district used 572.4 gallons in the same period of time.

"When the well's dry, we know the worth of water" - Benjamin Franklin
## Risk Management

**Dealing with Greywater System**

<table>
<thead>
<tr>
<th>No.</th>
<th>Risk</th>
<th>Effect on Project</th>
<th>Likelihood</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Labor shortage</td>
<td>Project delayed; Increased costs</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Some residents refuse installation</td>
<td>Consumption levels remain high</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Citizens disconnect the system</td>
<td>Consumption levels remain high; Increased costs</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High maintenance costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Poor equipment quality</td>
<td>Citizens reject system; Consumption remains high.</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Equipment consumes high electricity</td>
<td>High electricity bills</td>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>
# Risk Management

After Mitigating Risks

<table>
<thead>
<tr>
<th>No.</th>
<th>Risk</th>
<th>Risk Actions</th>
<th>Likelihood</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Labor shortage</td>
<td>Hire independent subcontractors</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>Some residents refuse installation</td>
<td>Penalty fee for non-installation</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Citizens disconnect the system</td>
<td>Penalty applied; inspectors monitoring average monthly consumption</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Poor equipment quality</td>
<td>Send inspectors regularly; Provide service hotline</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Equipment consumes high electricity</td>
<td>Use efficient “smart” equipment, only operates when needed</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
## Verification & Validation

<table>
<thead>
<tr>
<th>Requirements/Verification</th>
<th>Test</th>
<th>Demonstration</th>
<th>Inspection</th>
<th>Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>The system shall reduce water consumption in Saudi Arabia by 16-40%.</td>
<td></td>
<td></td>
<td></td>
<td>Analyze residents’ average consumption before and after implementation.</td>
</tr>
<tr>
<td>The system shall be capable of determining leaks in the water pipes network.</td>
<td></td>
<td></td>
<td>Inspectors will check water pipes regularly.</td>
<td></td>
</tr>
<tr>
<td>The system shall apply to new homes and existing homes.</td>
<td></td>
<td>NWC database of customer can be matched with those that have the system installed.</td>
<td>Inspectors will check that the equipment is installed on all homes.</td>
<td></td>
</tr>
<tr>
<td>The system shall meet with specifications and standards for the water provider.</td>
<td></td>
<td>Management group between MoWE and NWC to check that specifications are met.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The system shall provide accurate usage reports for water users.</td>
<td></td>
<td>NWC will test the equipment.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Conclusions

- There is a lack of understanding in KSA how water is vastly important for us.
- The project analyzes water consumption in residential areas, and how to reduce it.
- Greywater is very important for achieving low water consumption in residential areas, between 16 – 40%.
- MOWE & NWC stand beside citizens and help them to reduce the water consumption and water bills.
- System architecture was used to aid in visualizing the future systems.
- Modeling and surveys were used to support the decision of the chosen solution to the problem.
- The project verified all requirements and validated based on four methods.
- The ethics of people involved in the system such as a lack of community respect was discussed.
Lessons learned

- Having hands on experience with SE processes such as how to deal with the whole system first, and applying implementation processes which I used in my project.

- I have gained a lot of useful knowledge from my Systems Engineering major.

- Systems Engineering plays a very vital role in ensuring the success of a project.
Thank you for listening
Questions?

THINK ABOUT
WHAT YOU COULD SAVE
WHEN YOU SAVE WATER.
Resources

3. https://www.saudiembassy.net/about/countryinformation/agriculture_water/Water_Resources.aspx