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

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Overview

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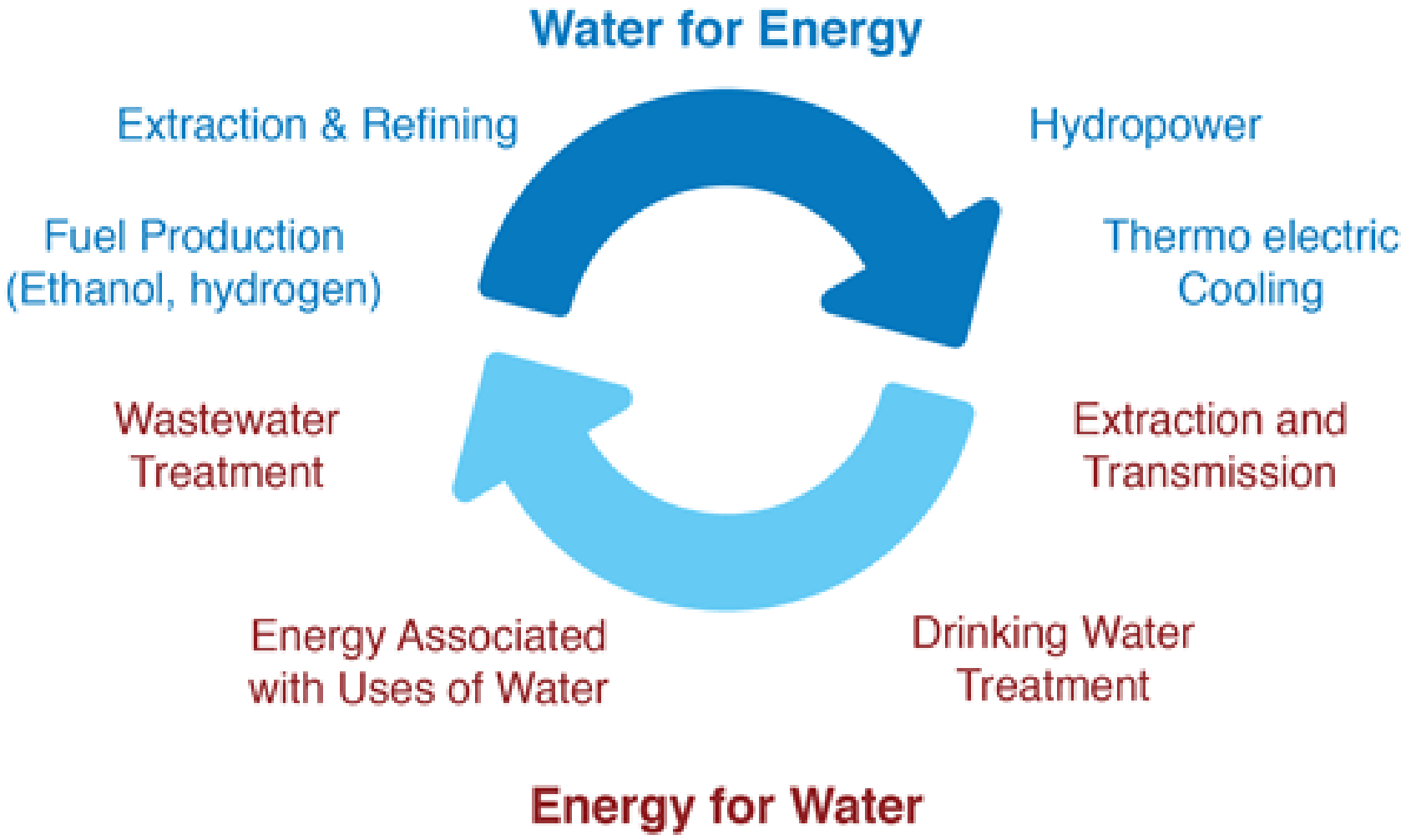
Introduction



The main objective of the study:

"Bridge the water-energy nexus knowledge gap to understand current nexus relationship and dynamics in the region"

- Quantitative data (energy tag in water/water tag in energy).
- Nexus associated environmental externalities (GHGs).
- Management alternatives and recommendations to save water & energy.

Desired outcome:

- Formulating and implementing nexus management approach for water and energy at a country level.

Methodology

- The method adopted is a case study review using **Eastern Province of Saudi Arabia** as study area.

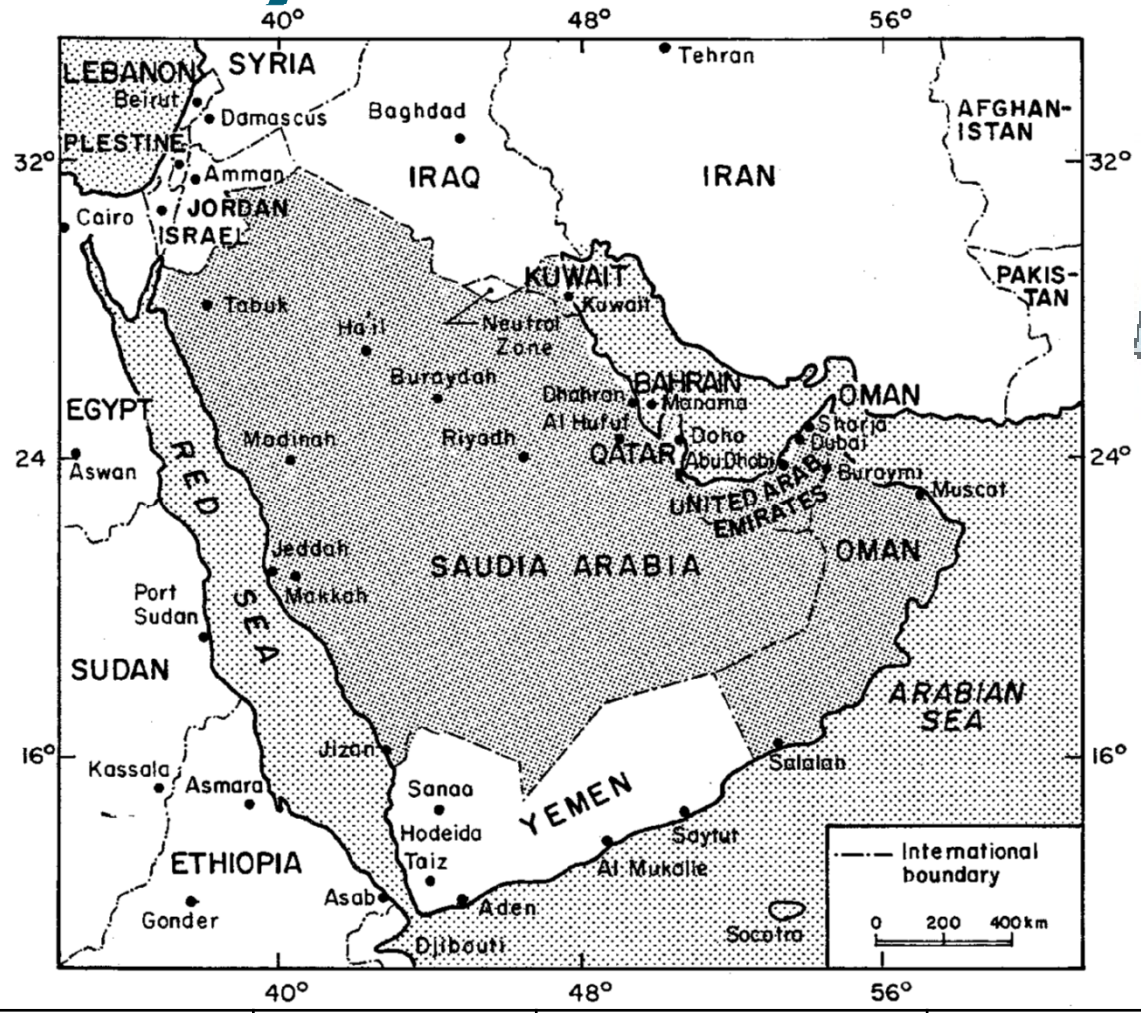
- Scope: Energy in water cycle, water in energy generation.

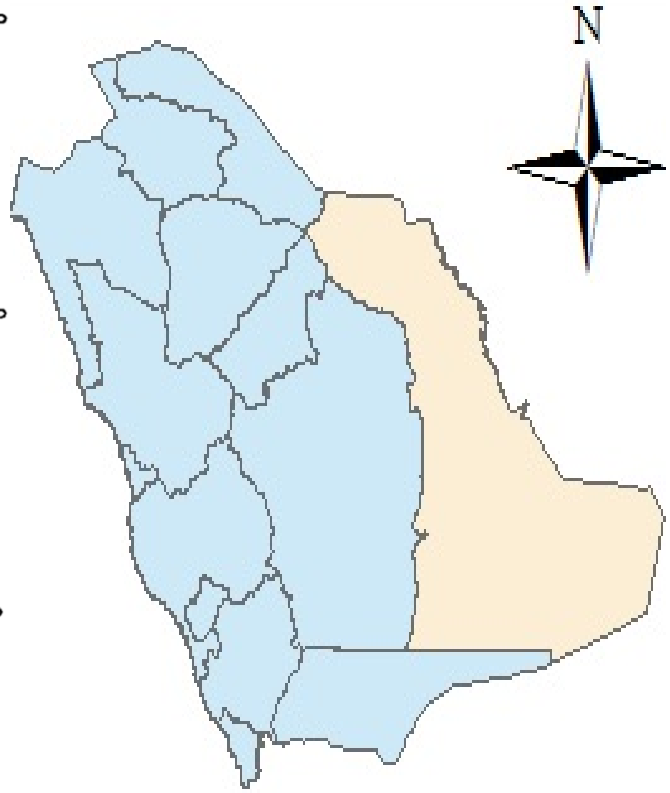
- Data gathered mainly from operating plants, published Saudi governmental water-energy authorities reports.

- An approved **mathematical equations** were utilized in estimating the water-energy nexus values.

$$\text{Energy (kWh)} = \frac{9.8\ \text{m s}^{-2} \times \text{Lift (m)} \times \text{Mass (kg)}}{3.6 \times 10^{6} \times \text{Efficiency (\%)}}.$$

Study Area

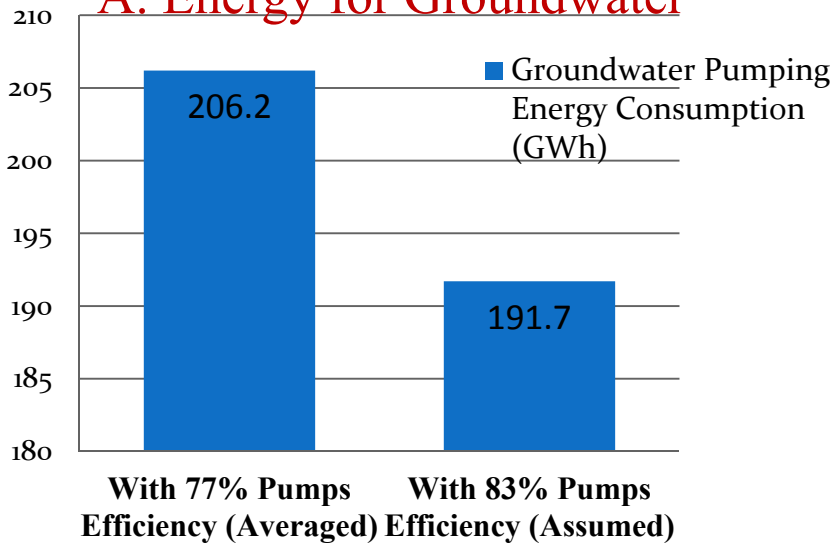




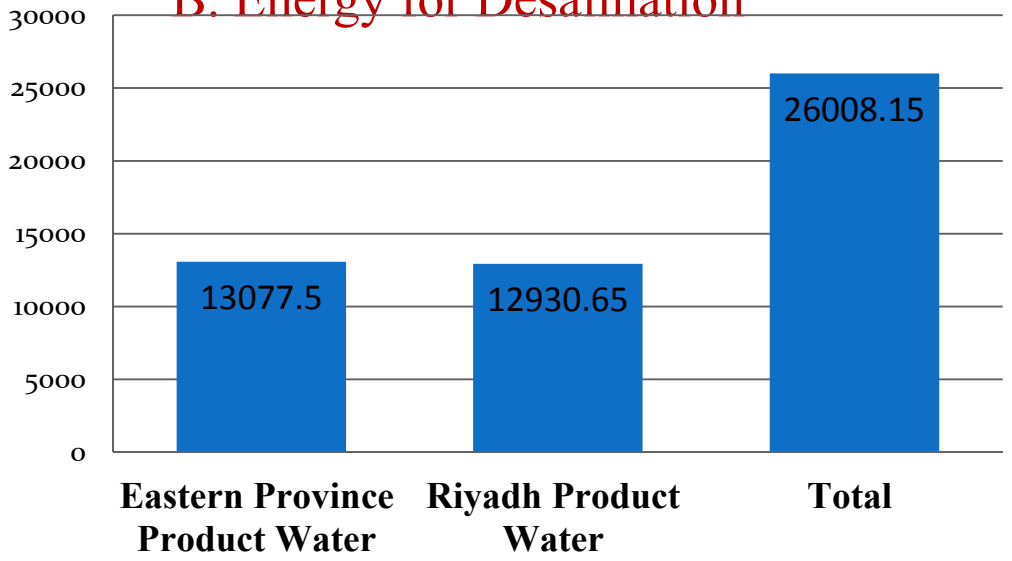
Population (2013)	Population GR	Water Demand (MCM, 2013)	Per capita Cons (CM, 2013)	Demand growth
4645516	3.7%	599	129	2.9%

Results 1. Energy for Water

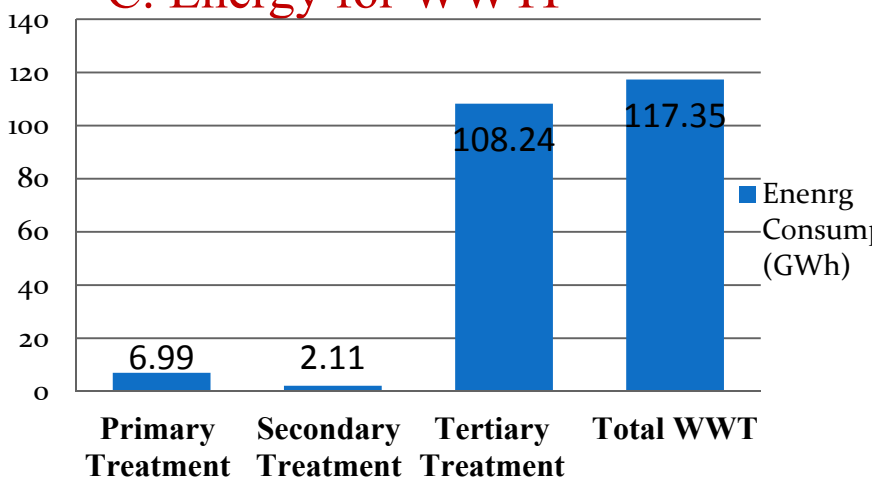
A. Energy for Groundwater

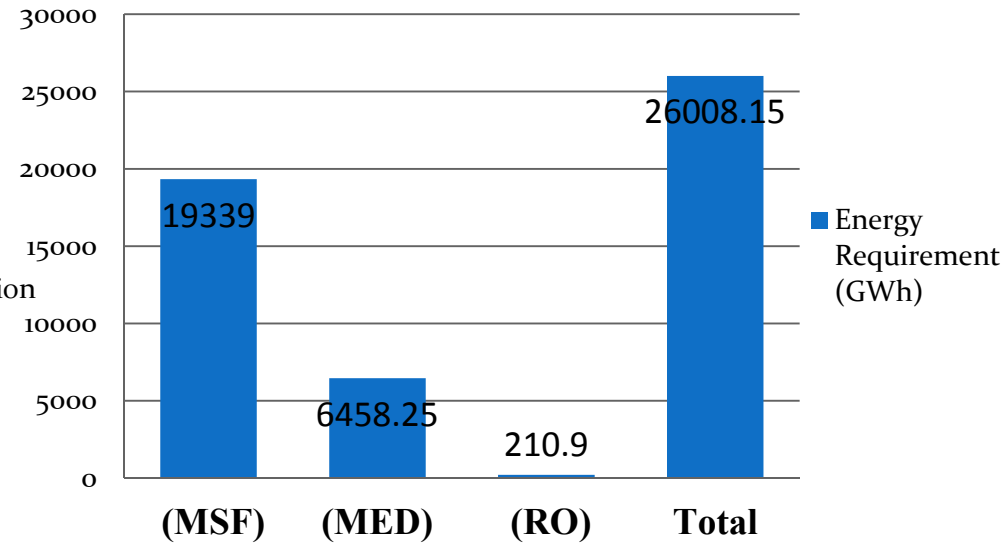


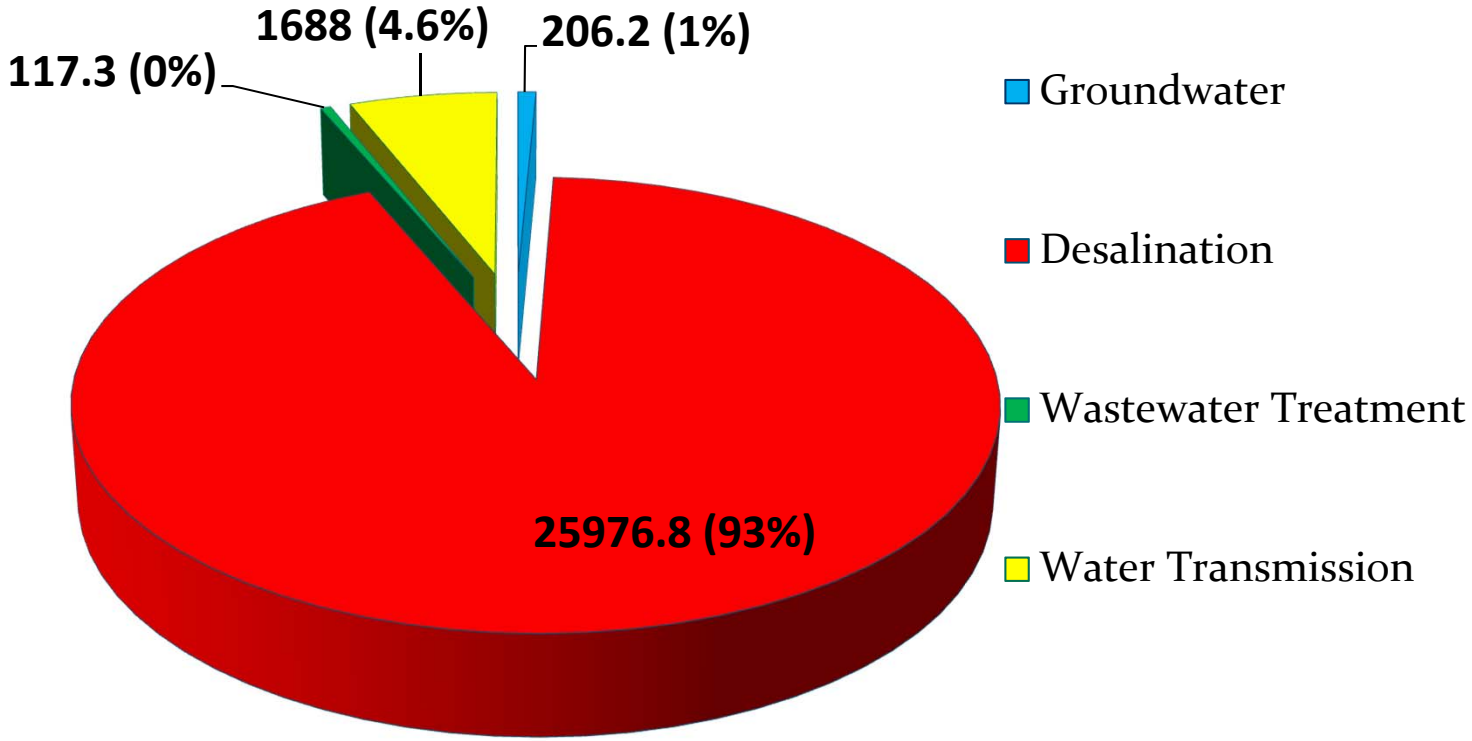
B. Energy for Desalination



C. Energy for WWTP

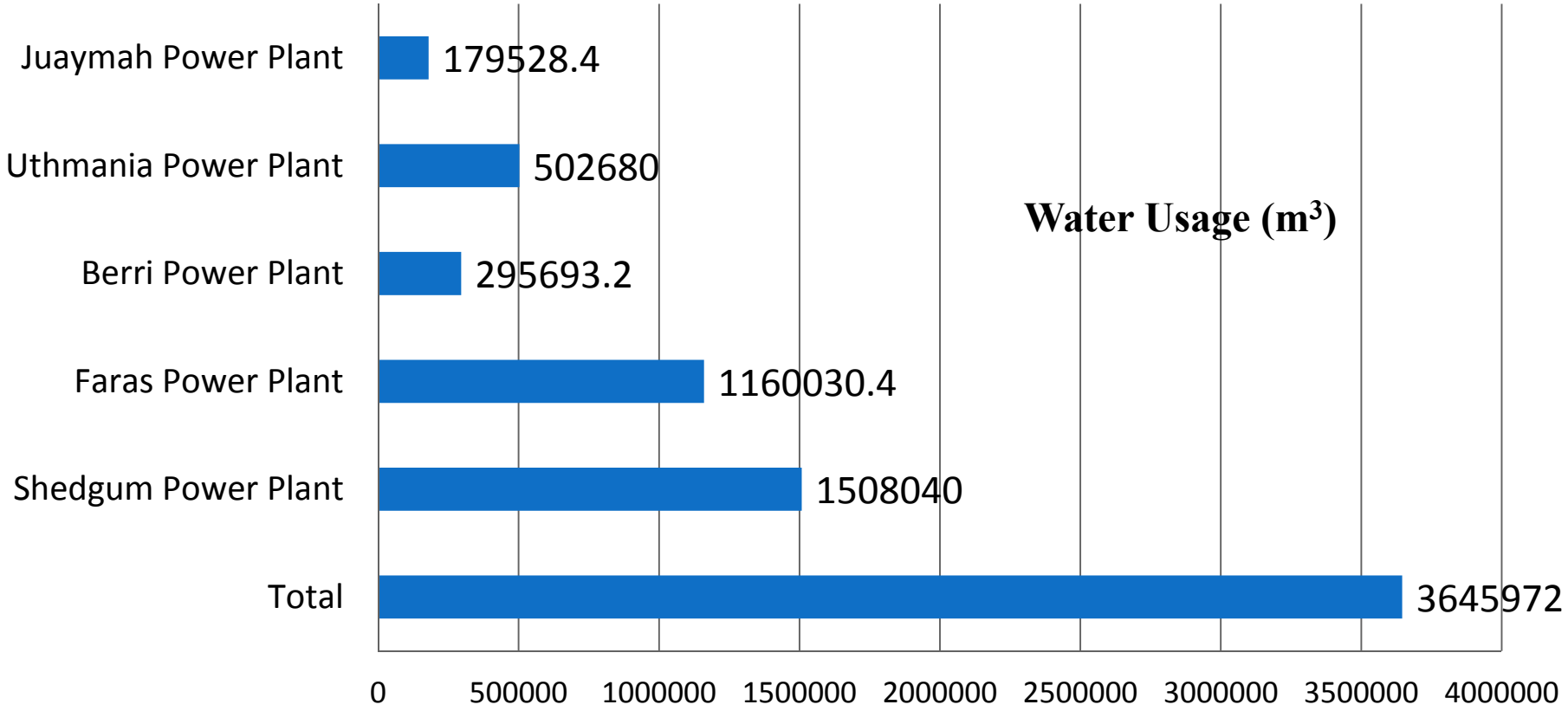






Water Value Chain (Groundwater, Desalination and WWTPs) Electric Energy Consumption in 2013 at the Eastern Province, in GWh and percentage.

Results 2. Water for Energy

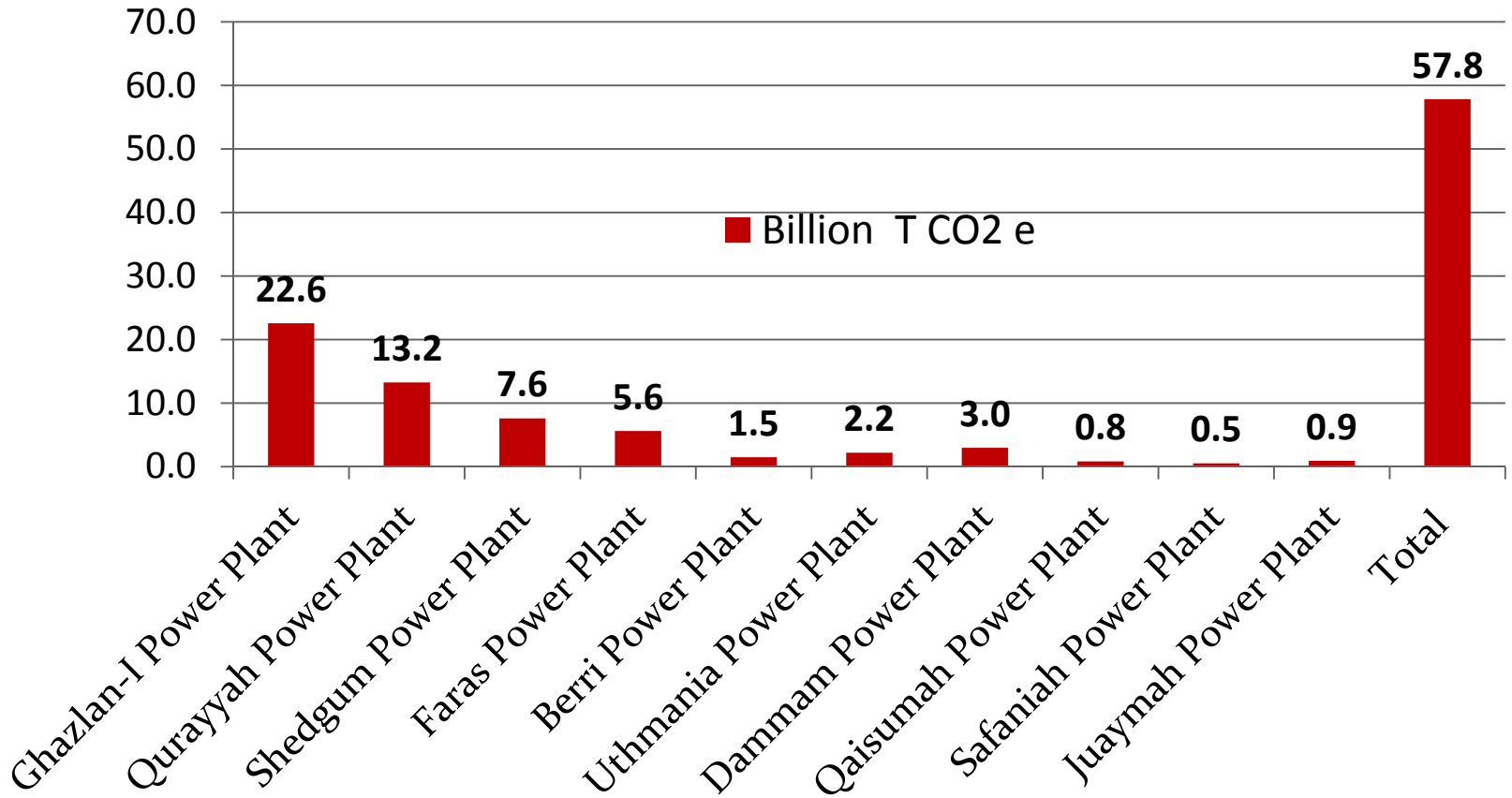


	Total	Shedgum Power Plant	Faras Power Plant	Berri Power Plant	Uthmania Power Plant	Juaymah Power Plant
Water Usage (m3)	3645972	1508040	1160030.4	295693.2	502680	179528.4

Cooling Water Requirements in Thermal Power Plants of EP Average 0.125 m^3/MWH

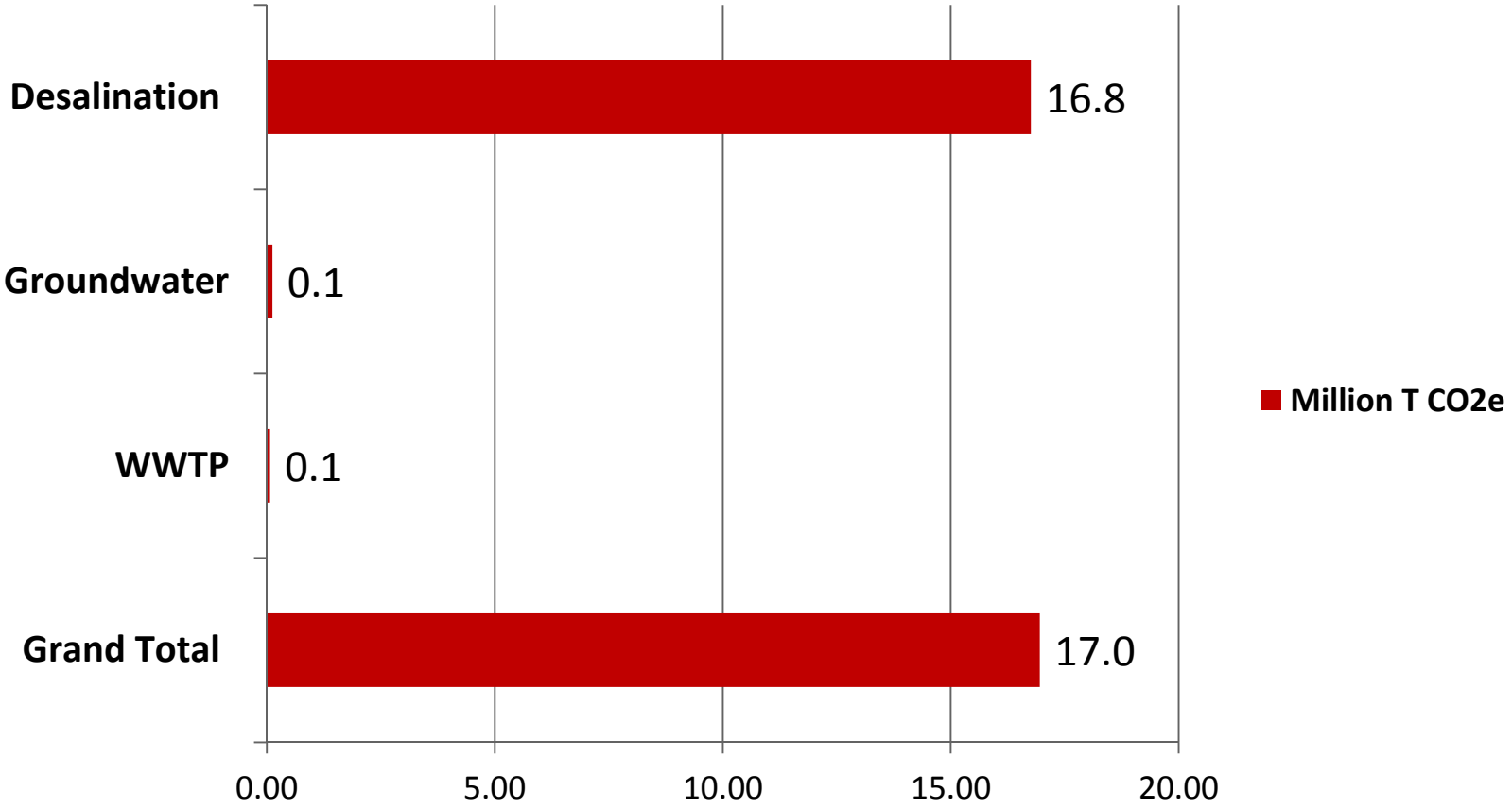
Results 3. GHG emission

Electric Power Plants CO_2 Emission in Eastern Province (2013 Design Capacity).



Results 3. GHG emission

CO_2 Emissions from Eastern Province Water Value Chain.



MITIGATIONS MEASURES

A. Raising conservation awareness and water saving devices

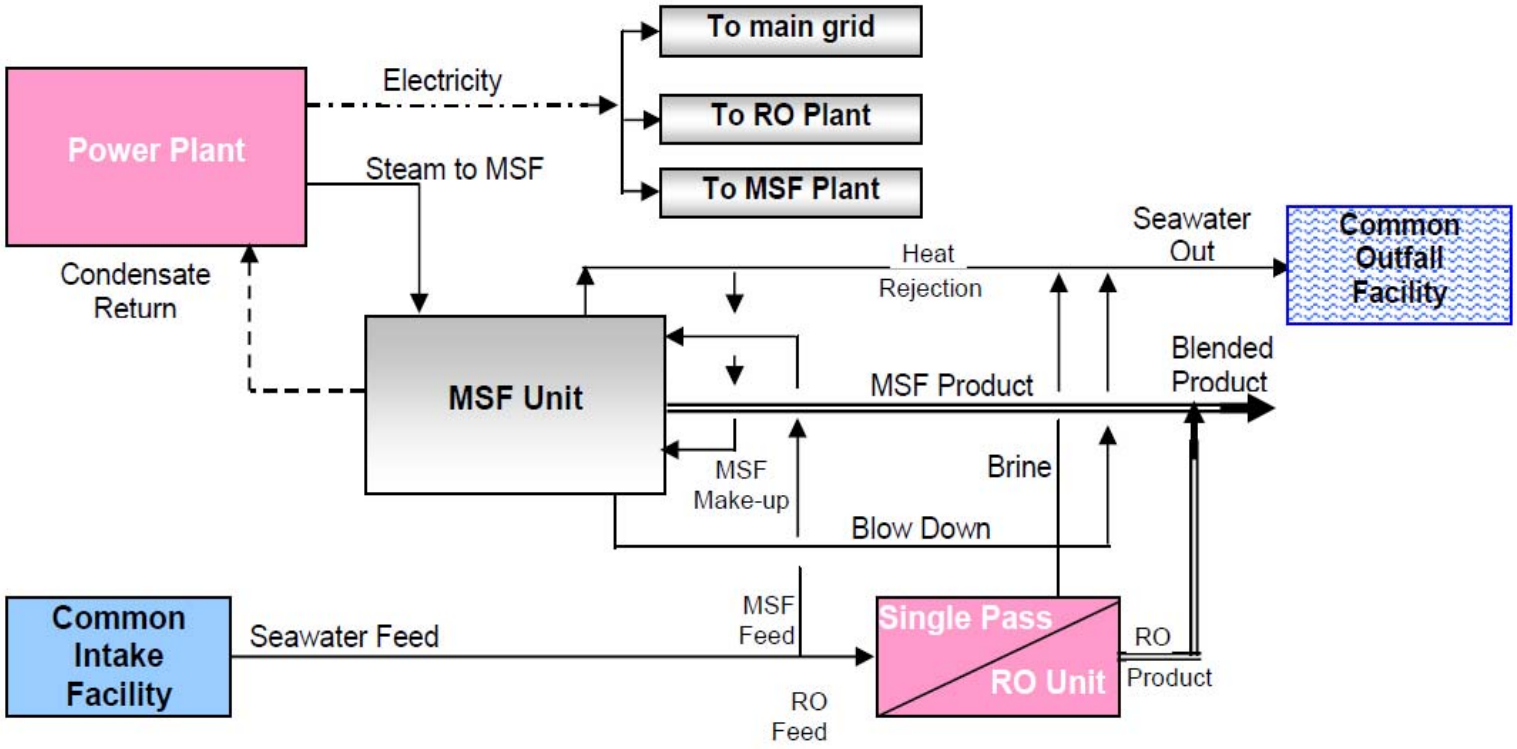
- Reduce consumption by 10% in municipal sector
- Water saving devices could save up to 20%
- Per capita consumption of Eastern Province from 129 to 91 m^3 per capita, 176 MCM could be saved.

B. BWRO as a potential supply to Riyadh

The provision of water to the capital Riyadh through Brackish Water RO (BWRO) proven to be more energy efficient (requires less energy 4.4 kWh/m^3) compared to the coastal Salt Water RO (SWRO) (11.6 kWh/m^3) or MSF (45.7 kWh/m^3)

C. Hybrid Desalination

The hybrid configuration **(MSF/RO)** offers various operational flexibility, economical, energy and environmental advantages.



D. Renewable Energies

E. Treated effluent as coolant in power plants

Conclusion

- **Water and energy are inevitably linked and interrelated in Saudi Arabia**. Substantial Energy goes into water production specifically thermal MSF/MED desalination, large volumes of water are being used in energy production.

- The Eastern Province's water-energy nexus is affected by the distance from coastal area of the Arabian Gulf. **The area's water dependency on energy is more prevalent.**

- **Riyadh water provision** (through coastal desalination and conveyance) is a **key feature of the water-energy nexus** in the Eastern Province which influences the shape of the nexus significantly.

- GHG emission from water cycle exceeded **15 Million Tons** of CO_2, mainly attributed to thermal desalination, CO_2 from power plants was **3000 times** that associated with entire water cycle at Eastern Province.

- Energy requirement for the entire water cycle represents **5% of the Kingdom total electric generation capacity and 13% of Eastern Province**. Largely dominated by thermal desalination operation and transmission.

- Water management **is highly dependent on energy, and energy generation is highly reliant on water resources** specifically as we move inland. Desalination cannot be ruled out but it can/should be made more environmentally friendly. Water for cooling is not sustainable option in energy sector.

Recommendations

- Reduce energy consumption in water supply chain (**specifically MSF**) through increased process efficiency and, using renewable energies or hybrid systems.

- Water usage at power plant should be minimized (**using treated effluent as cooling medium**) or elimination by adopting other cooling technologies; e.g., dry cooling or others.

- Energy generation through fossil fuel **is not a sustainable and contributes largely to GHG**. Therefore, renewable energy generation is highly recommended. Support and implement initiatives related to solar/geothermal desalination, solar or wind groundwater, energy recovery from WWTP.

Recommendations

- **Assess the feasibility/sustainability of BWRO to produce Riyadh water.** Renewable energy (preferably solar) in water transmission operation to Riyadh form coastal desalination (RO) is recommended.

- **It is recommended to conduct similar research on the nexus employing water and energy modeling software preferably WEAP-LEAP** programs which could result in a more precise and long-term representation of W-E nexus.

- There is no integrated water-energy R&D entity in GCC. **Overlapping R&D is necessary** as per the nature of water-energy nexus to achieve best available results. A mechanism to **initiate and conduct integrated water-energy R&D is recommended.**

Thank You

Special thanks to:

- *(AGU) Prof. Waleed Prof. Ibrahim & Dr Alaa.*
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