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5. Utilities 1: Water Management

Mel Slade, IEA

Pretoria, 15 October 2019

IEA #energyefficientworld

Training Overview

Utilities: Water Management

Scenario: Local residents are complaining about unreliable and costly drinking water supply

Question: What can you do to reduce energy use in the water sector and improve service delivery?

Training Overview

1. **Energy use in water**
   - Context: Water-energy nexus, increasing demand
   - Drivers of energy use

2. **Tools: Strategies for energy efficiency**
   - Reducing energy use; recover energy; time energy use

3. **Activity : Barriers to water energy efficiency**

10 mins

10 mins

30 mins

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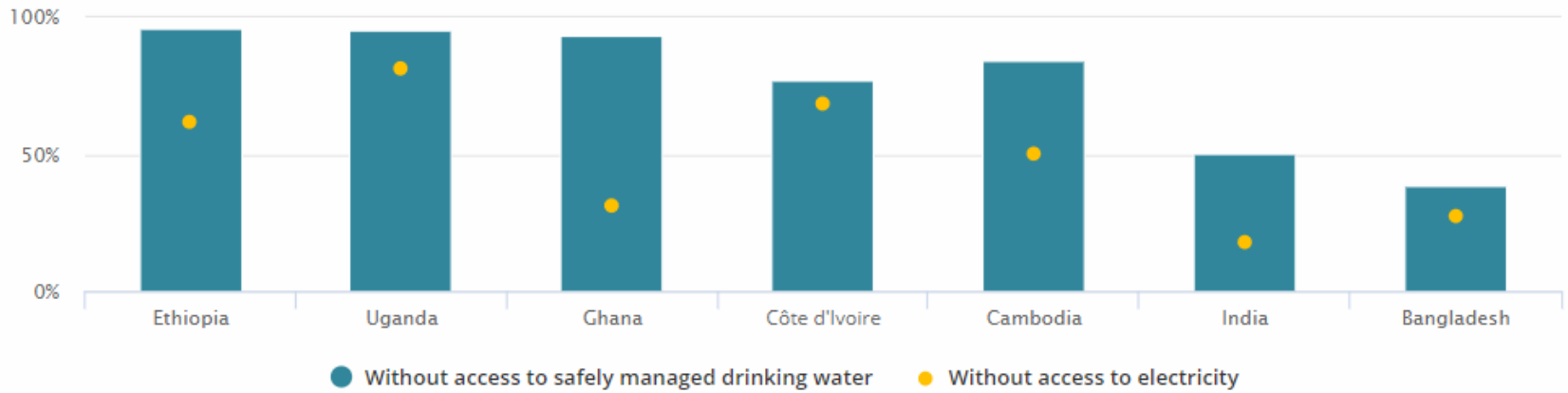
Training Overview

- This session starts the municipal services section. Like other sessions we first call attention to the water sector and the importance of sustainable water service through energy efficiency
- We examine the drivers of energy use in the water sector as this will be the basis of energy efficiency programmes in the water sector.
- We then go to a structured discussion of case studies of how energy efficiency is implemented, from energy use reduction, energy recovery, and demand side response.
- The activity is designed to organise the thoughts of participants towards consequences of barriers and the solutions possible. This allows them to map out possible barriers that might be silently affecting their revenues, hence their ability to take out a loan for EE investments.

1. Energy use in water

1. Energy use in water: Context

Share of population without access to electricity or water in rural areas



Access to safe drinking water and energy costs associated with it remains a challenge in developing and emerging economies

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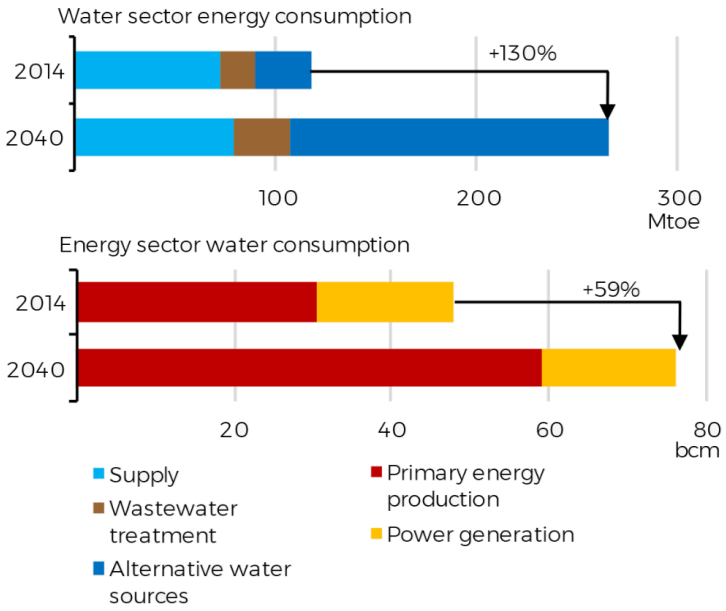
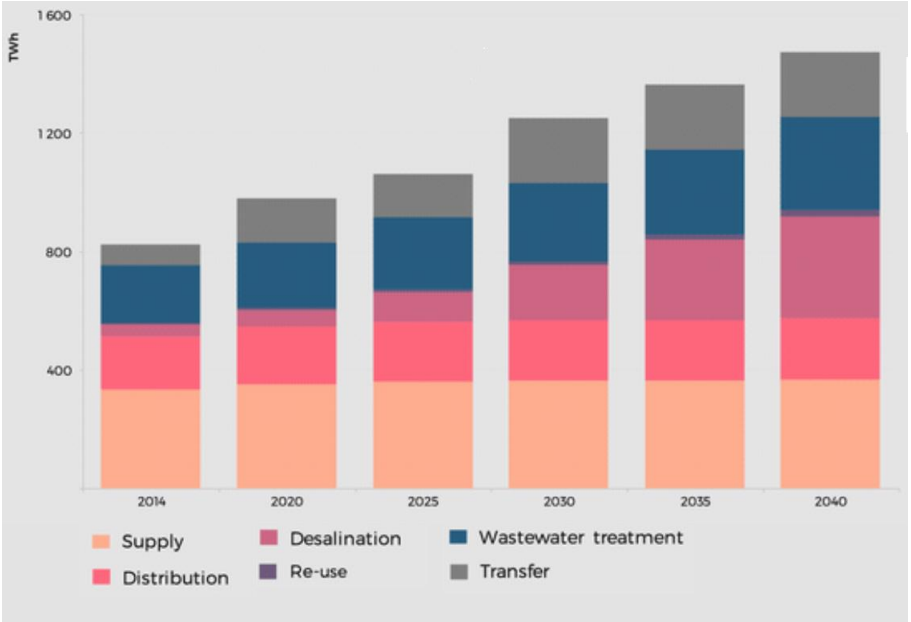
1. Energy use in water: Context

Energy and water sector consumption



Electricity consumption in the water sector by process, 2014-2040

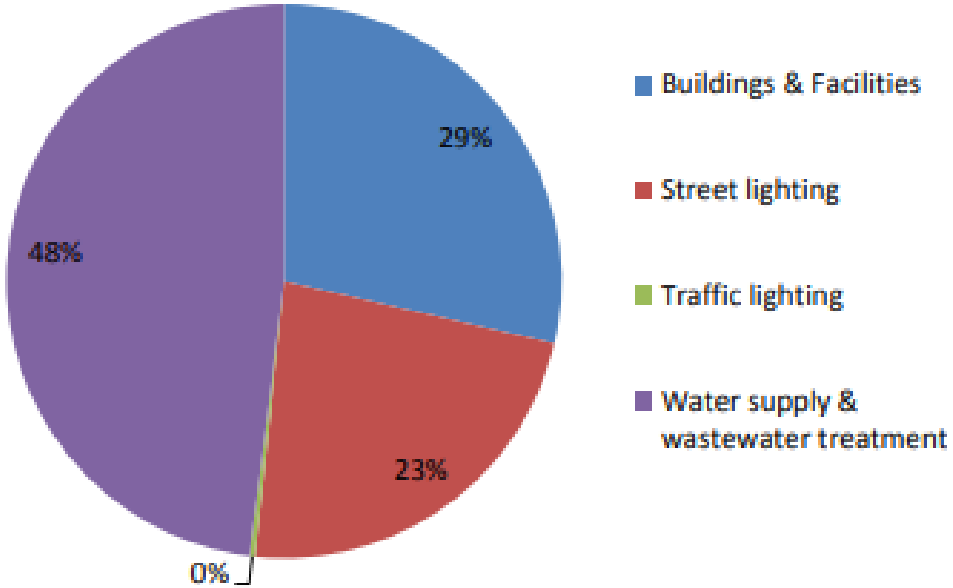


Energy is needed to obtain, process, and distribute water and water is also needed to keep energy services running. Energy efficiency is hence, important to provide both services

Source: https://www.iea.org/reports/water-

1. **Energy use in water:** Context in South Africa

Potential electricity savings per Sector (MWh/a) in 9 cities of the South African Cities Network (SACN)



The water supply and wastewater treatment sectors have the highest electricity efficiency savings potential among the electricity consuming sectors in South African municipalities.

Source: South African Cities Network (2014) http://sacitiesnetwork.co.za/wp-content/uploads/2014/07/Modelling-Energy-Efficiency-Potential-in-SACN-Cities-full-report.pdf

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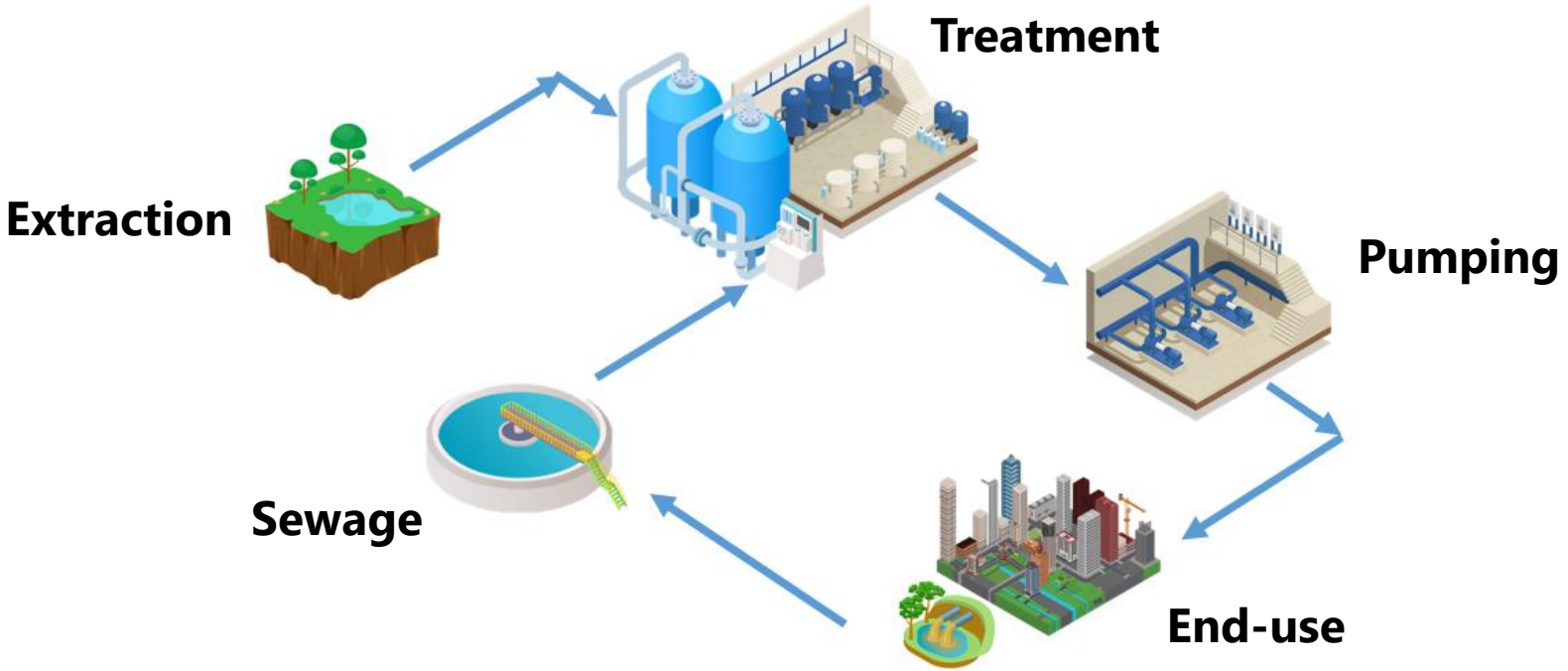
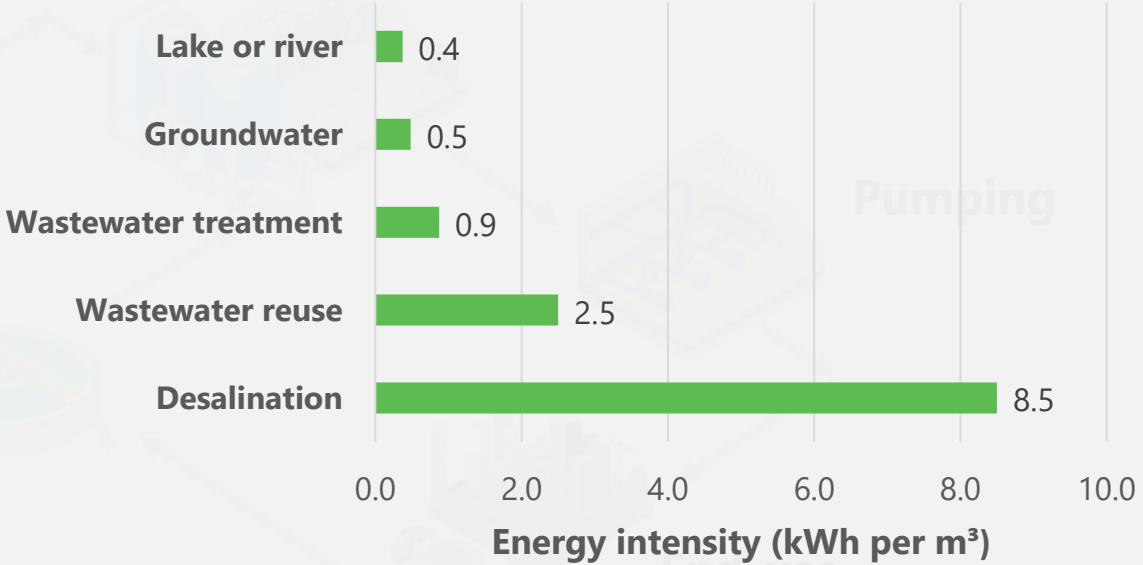
1. Energy use in water: Drivers



1. **Energy use in water:** Drivers - Extraction

Extraction



Source: EPRI Water and Sustainability Volume 4 https://www.epri.com/#/pages/product/1006787/

Source and location of water for extraction dictate the complexity of treatment and add extra energy use

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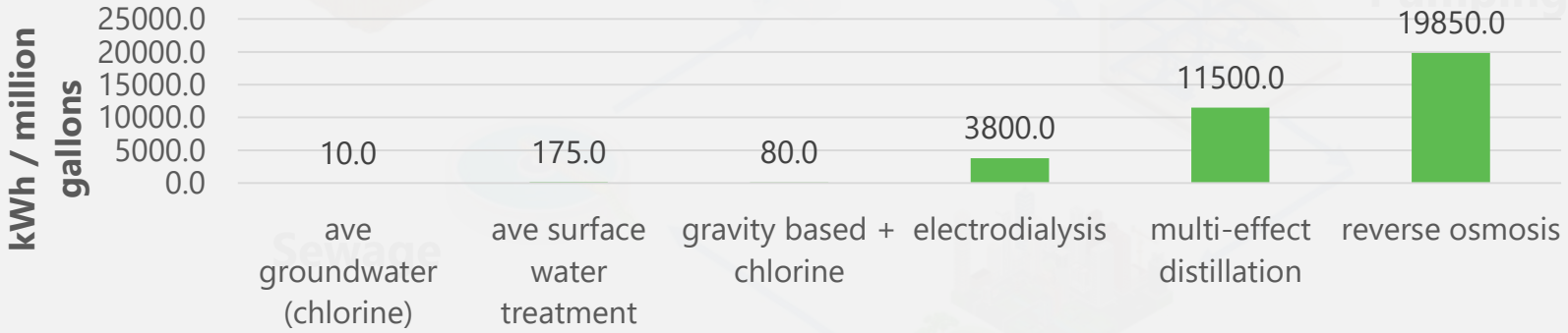
1. **Energy use in water:** Drivers - Treatment



Source: https://www.researchgate.net/publication/257935517_The_unintended_energy_impacts_of_increased_nitrate_contamination_from_biofuels_production/figures?lo=1

Treatment technologies affect energy consumption and is highly influenced by the source of the raw water

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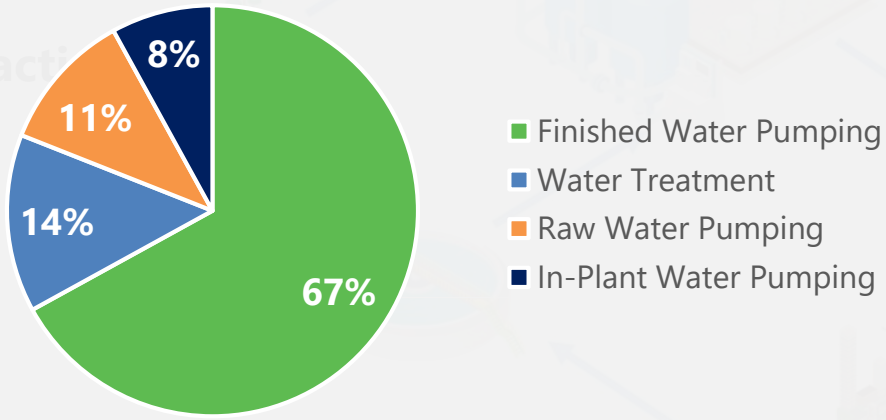
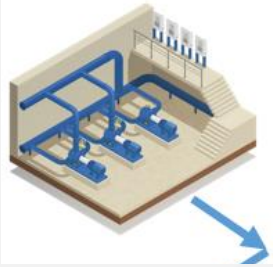
1. **Energy use in water:** Drivers - Pumping





Pumping

Source EPRI Solutions (2005). Bringing Energy Efficiency to the Water & Wastewater Industry: How Do We Get There? WEFTEC

Pump motors run almost non-stop. Improperly sized pumps or inefficient motors result to higher energy cost. Technologies like VFD ensure high efficiency even with varying demand

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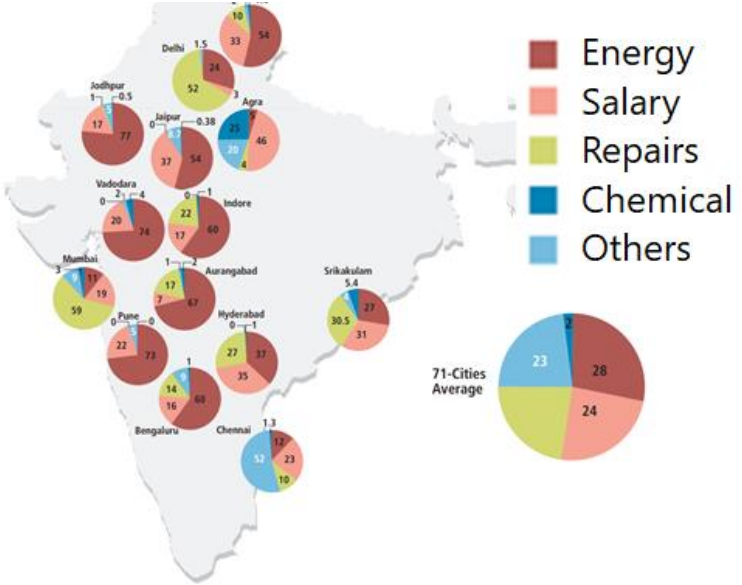
1. **Energy use in water:** Drivers - Distribution and end-use

Energy costs in Distribution in India



Leakage in distribution is estimated to contribute to additional **11% losses**

Source Mainstreaming Energy Efficiency in Urban Water and Waste Water, Centre for Science and Environment India 2017, Excreta Matters 2012 CSEI

End-use

Leakages, blockages, and scales in piping all contribute to higher pumping energy use for the same water service delivered

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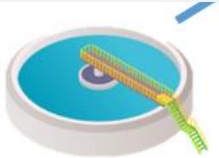
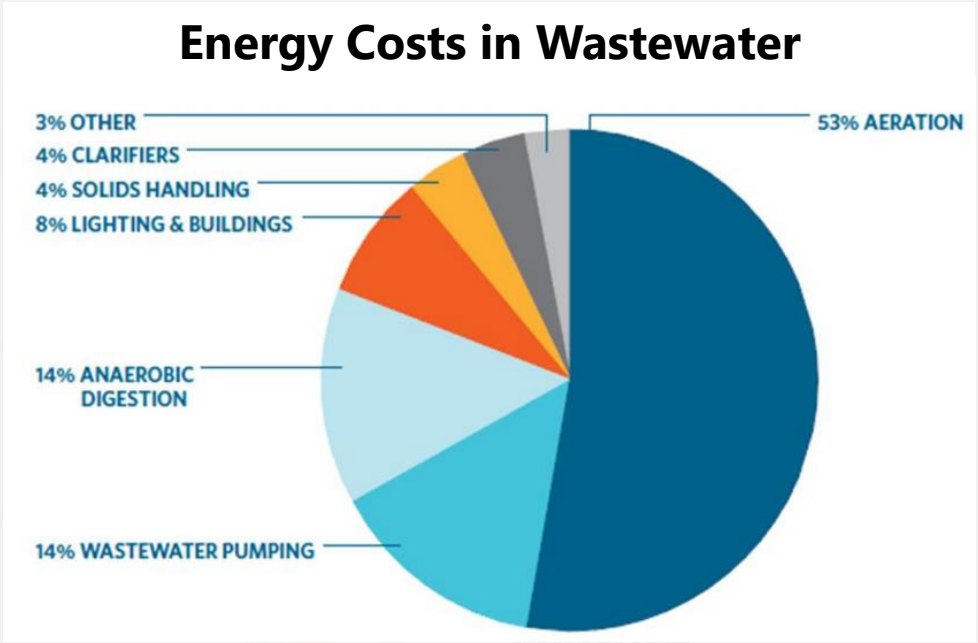
1. **Energy use in water:** Drivers - Sewage treatment



Sewage



Source: Wastewater Treatment Energy Savings Guide: Energy Trust of Oregon

Sewage treatment depend on the conditions of the wastewater, but the major contributor to cost is the efficiency of the aerators and their motors

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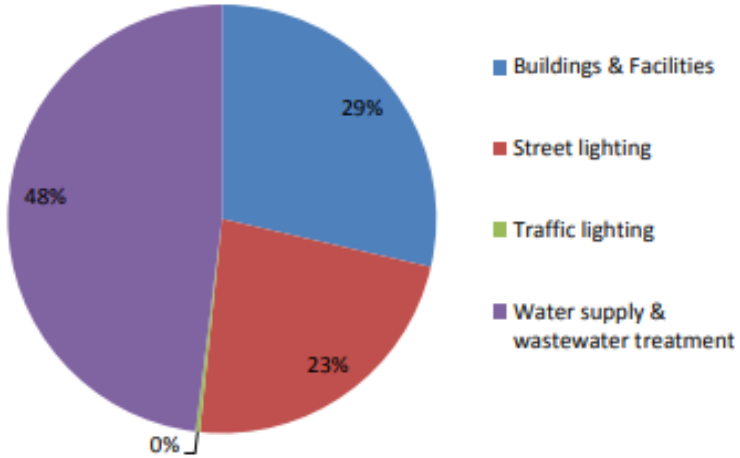
1. Energy use in water: South Africa's municipal context

Potential electricity savings per Sector (MWh/a) in 9 cities of the South African Cities Network (SACN)



Example of Energy Savings Performance Contract for Water Loss Reduction and EE Improvement in Emfuleni

- Competitive bidding process
- Municipal water utility Metsi-a-Lekoa of Emfuleni signed a water and energy performance contract with WRP Engineering Consulting Company under BOT- 5 year contract
- "Shared savings agreement" in the contract: WRP received remuneration based on verified energy and water savings

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2. Tools: Strategies for energy efficiency

2. Tools: Strategies for energy efficiency

Reduce Energy use

- Energy management systems
- Improve motor efficiencies
- Improve controls

Recover Energy

- Anaerobic biodigestion of sewage to recover energy

Time Energy use

- Stagger activities towards off-peak hours

2. Tools: Strategies for energy efficiency

Reduce Energy use

- **Energy management systems**
- Improve motor efficiencies
- Improve controls

- **Energy management systems** allow an organised approach of measurement and operational action towards saving energy

- **Example: Brasilia Federal District Water EnMs**
  - Growing population, informal urban settlements, old pipes
  - Growing difficulty to provide service as demand increases
  - The provision of **management systems allowed systematic** identification of **water loss as major problem** due to adoption of management system.

http://www.acquacon.com.br/waterloss2010/presentations/day7/17h00eltongoncalvesdia07sala2.pdf

2. Tools: Strategies for energy efficiency. Reduce

Reduce Energy use

- **Energy management systems**
- Improve motor efficiencies
- Improve controls

- **Example: Brasilia Federal District EnMs (major steps)**
  - Conducted auditing and data collection
  - Summarize sources of energy consumption

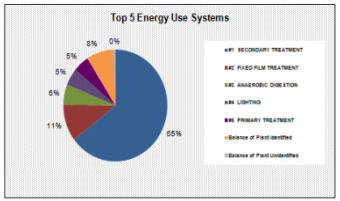
Specify Other Utility Type (if any)	Propane
Specify Units for Other Energy Consumption (if any)	GAL

2011

Electric ($/kWh)	$0.1018	Natural Gas ($/CCF)	$1.150

2011	January	February	March	April
Electricity Cost ($) 2011	$18,184.32	$19,492.46	$19,247.76	$19,704.16
Consumption (kWh) 2011	196,800	193,800	187,600	192,800
Natural Gas Cost ($) 2011	$6,146.54	$5,556.68	$5,015.30	
Consumption (CCF) 2011	5,276	4,782	4,331	
No 2 Fuel Oil Cost ($) 2011	$16,231.03	$11,166.71	$8,587.05	
Consumption (CCF) 2011	14,260	10,279	8,478	5,237
Water & Sewer Cost ($) 2011	$12,320.06	$12,320.06	$11,741.82	$11,741.82
Consumption (GAL) 2011	2,210,986	2,210,986	2,107,257	2,107,257
Alternative Energy Cost ($) 2011	$1,914.90	$2,035.80	$2,571.40	$2,394.60
Consumption (CCF) 2011	1,473,000	1,566,000	1,978,000	1,842,000
Other - Propane Cost ($) 2011	$1,070.30	$1,535.60	$2,324.30	$3,180.10
Consumption (GAL) 2011	973,000	1,396,000	2,113,000	2,891,000
Total Utility Cost 2011	$55,867.15	$52,107.31	$49,487.63	$45,391.0
Treatment Volume (MGAL) 2011	112,240	107,500	116,700	118,400
Utility Cost/Treatment Volume ($/MG	$497.75	$484.72	$424.06	$383.3
Electric Utilization (kWh/MGAL) 2011	1,753.39	1,765.58	1,607.54	1,628.3

DISTRIBUTION OF ELECTRICAL ENERGY USE & COST BY MAJOR PROCESS FOR 7/2010 - 6/2011



Major Process/Top Energy Use Systems	Electric Energy Use (%)	Electric Energy Use (kWh)	Electric Energy Cost ($)
#1 SECONDARY TREATMENT	64.60%	1,452,103	$146,953
#2 FIXED FILM TREATMENT	10.62%	238,639	$24,150
#3 ANAEROBIC DIGESTION	5.88%	132,289	$13,388
#4 LIGHTING	4.98%	111,865	$11,321
#5 PRIMARY TREATMENT	4.89%	109,930	$11,125
Balance of Plant Identified	8.51%	191,404	$19,370
Balance of Plant Unidentified	0.52%	11,770	$1,191
Total	100.00%	2,248,000	$227,497

EQUIPMENT INVENTORY: BREAKDOWN OF ELECTRICAL ENERGY USE FOR MAJOR/ENERGY INTENSIVE EQUIPMENT

Major Process/Top Energy Use Systems	Motor Efficiency (%)	Efficiency Rating	Electric Energy Use (%)	Electric Energy Use (kWh)	Electric Energy Cost ($)
Anaerobic Digestion					
Mixer - Gas Mixer	88	Medium	2.48%	55,696	$5,636.40
Other kW Load - Mixer Heater	N/A	N/A	0.80%	18,000	$1,821.60
Pump - Ht Wtr Pumps	85	Medium	0.56%	12,581	$1,273.16
Pump - Sludge Ht Wtr Pumps	85	Medium	0.62%	13,979	$1,414.63
Pump - Sludge Recir Pump	85	Medium	1.43%	32,034	$3,241.85
Effluent Pumping/Storage					
Pump - Effluent Pumps	91	High	0.91%	20,363	$2,060.77

Images are representation only of the process undertaken and not the actual data of CAESB

Images from: https://www.epa.gov/sites/production/files/2016-01/documents/nrwa-energy-audits-for-small-utilities-8-4-14.pdf

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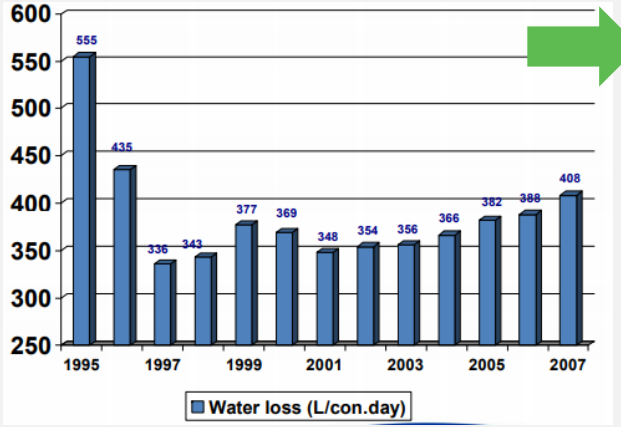
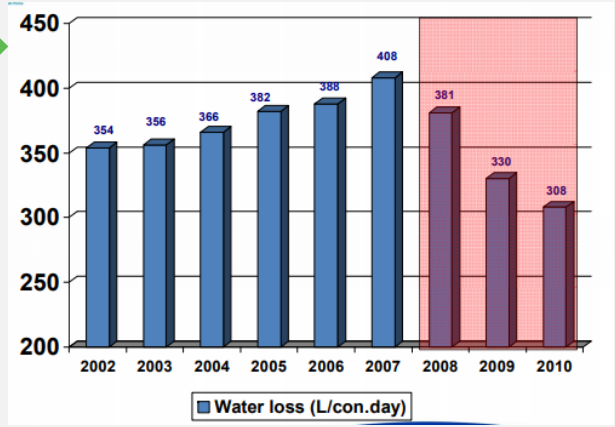
2. Tools: Strategies for energy efficiency. Reduce

Reduce Energy use

- **Energy management systems**
- Improve motor efficiencies
- Improve controls

- **Example: Brasilia Federal District EnMs**
  - EnMs allowed them to measure **costs of water losses**, identify **billing problems**, and find optimum solutions based on cost and benefit. Resulted to immediate **25% reduction in water loss and energy savings** in the first 3 years





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2. Tools: Strategies for energy efficiency. Reduce

Reduce Energy use

- **Energy management systems**
- Improve motor efficiencies
- Improve controls

- EnMS can be executed by third party through energy service performance contracts
- **Case study:** Water Loss Reduction and EE Improvement in Emfuleni
  - Competitive bidding process, "Shared savings agreement" where contractor received remuneration based on verified energy and water savings
  - **14, 250MWHr annual electricity savings**
  - **USD 3.8 M per year in savings**
  - **7-8 million m3 annual water savings**

Source: ESMAP, 2010, Good Practices in City Energy Efficiency, http://www.esmap.org/esmap/node/231

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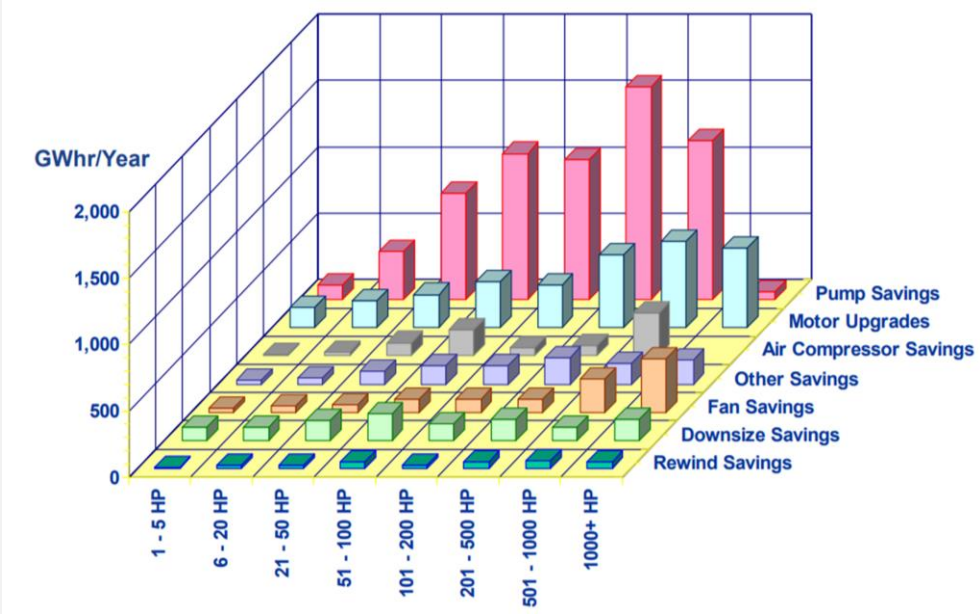
2. Tools: Strategies for energy efficiency. Reduce

Reduce Energy use

- Energy management systems
- **Improve motor efficiencies**
- Improve controls

- Replacing motors: Savings could **go up to 1500 GWhr/yr** depending on motor size and hours of operation



Source https://betterbuildingssolutioncenter.energy.gov

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2. Tools: Strategies for energy efficiency. Reduce

Reduce Energy use

- Energy management systems
- **Improve motor efficiencies**
- Improve controls

- **Example:** Motor replacement in wastewater aerators in Green Bay Wisconsin

50% reduction in electricity

2.14 GWh/year savings = 126 homes

Source https://www.epa.gov/sites/production/files/2015-08/documents/wastewater-guide.pdf

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2. Tools: Strategies for energy efficiency. Reduce

Reduce Energy use

- Energy management systems
- **Improve motor efficiencies**
- Improve controls

- **Example:** Motor replacement in pumping in Columbus Georgia

25% reduction in electricity

$250 000 in energy cost

1-year payback period

Source https://www.epa.gov/sites/production/files/2015-08/documents/wastewater-guide.pdf

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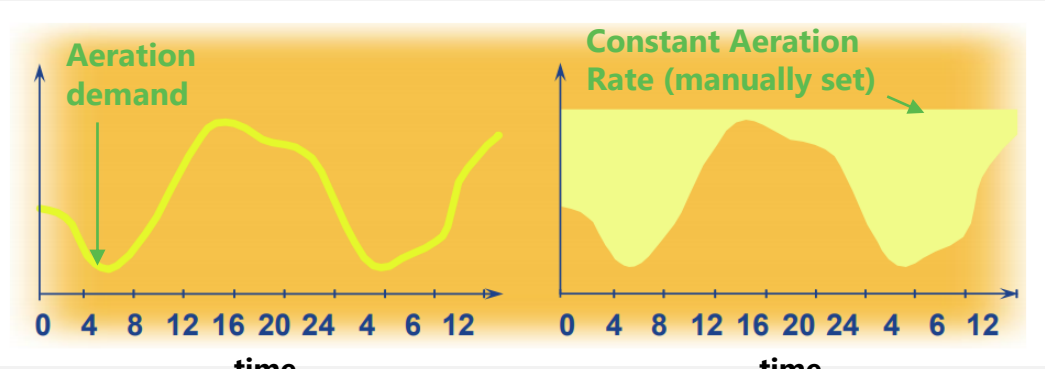
2. Tools: Strategies for energy efficiency. Reduce

Reduce Energy use

- Energy management systems
- Improve motor efficiencies
- **Improve controls**

- Fluctuations in biological load can change over a 24-hr period, hence aeration could be adjusted if it were automatic. **Manual or poor control** can cause excess energy use by as **much as 50-65%**



Source https://betterbuildingssolutioncenter.energy.gov

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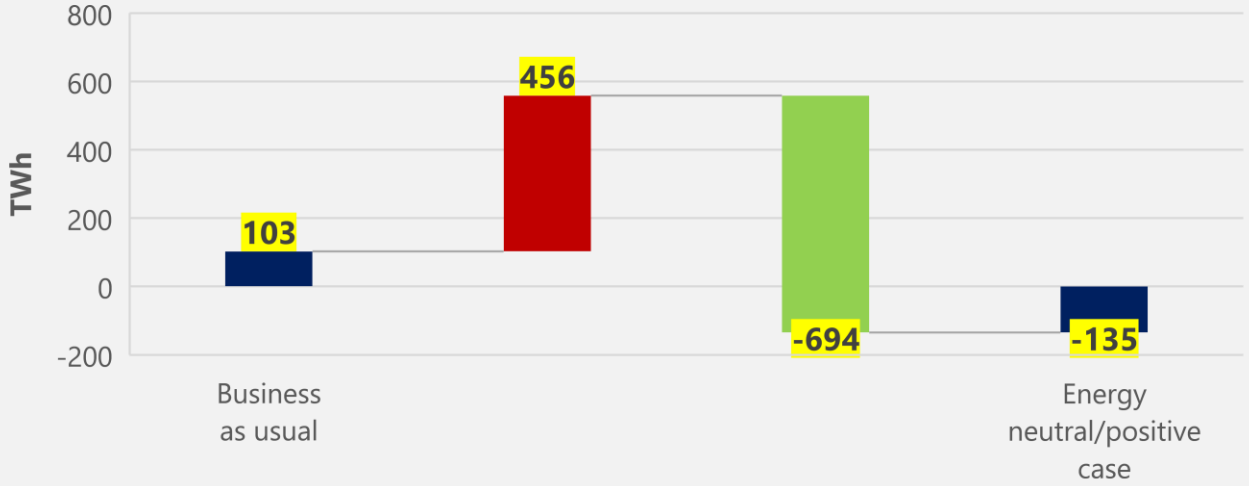
2. Tools: Strategies for energy efficiency. Recover

Recover Energy

- **Anaerobic biodigestion of sewage to recover energy**

- Ramping up energy recovery helps achieve SDG 6.2 (sanitation for all) and SDG 6.3 (halving the percentage of untreated water) by 2030



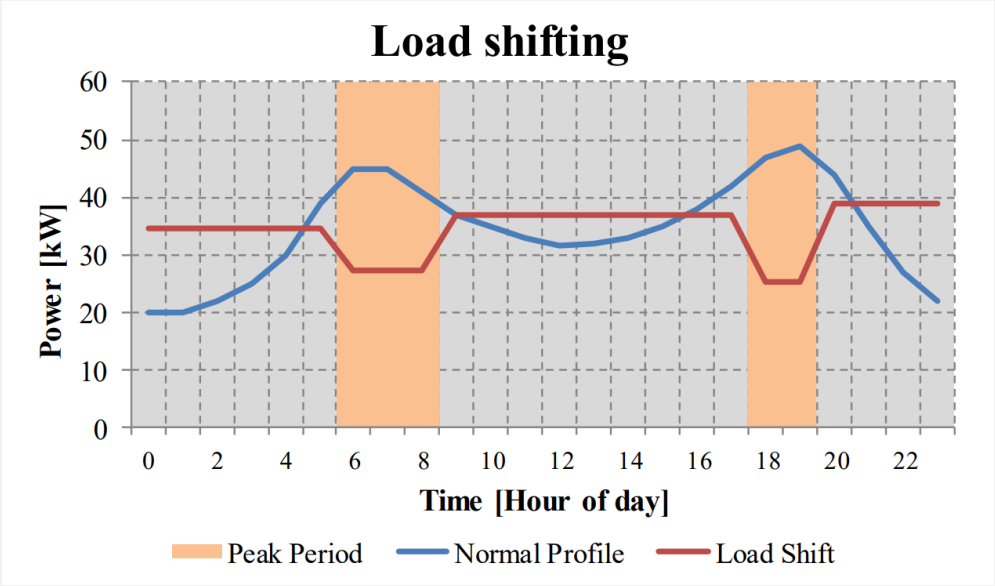
https://www.iea.org/weo/water/

2. Tools: Strategies for energy efficiency. Time

Time Energy use

- **Stagger activities towards off-peak hours**

- **Example:** South Africa study with **2.21MW** of load shift achieved, with around **69k USD annual savings**



https://repository.nwu.ac.za/bitstream/handle/10394/15212/Els_LA_2015.pdf?sequence=1

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2. Tools: Strategies for energy efficiency. Time

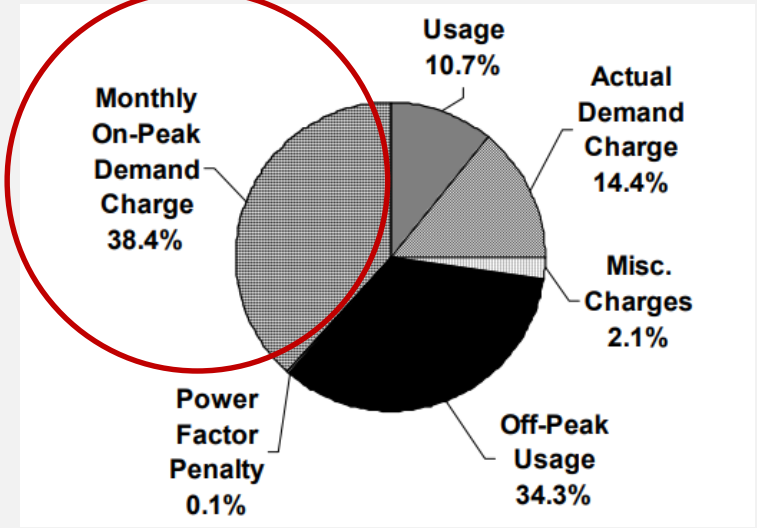
Time Energy use

- **Stagger activities towards off-peak hours**

- **Example:** Electricity cost savings and opportunities in Ann Arbor > shifting filter backwash cycles to off-peak reduced energy costs from demand

9000 USD investment

1500-2000 USD per month in cost savings



Note: share of energy consumption was established after investing in monitoring equipment (EnMS feature)
https://www.seventhwave.org/sites/default/files/222-1.pdf

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2. Tools: Strategies for energy efficiency. Other Strategies

- **Subsidies:** Are the subsidies targeting the right people? Are they consumed by the rich or the industrial consumers?

- **Financing:** Is billing and collection easy? Is budget secured?

- **Training:** Are the operators capable of spotting energy efficiency problems and conducting the repairs and improvements needed?

3. Activity

3. Activity

On three tables, discuss consequences and possible solutions on the following barriers: regulatory/institutional; economic; information/capacity

Regulatory/Institutional

Barrier	Consequence	Solution
…	…	…

Economic

Barrier	Consequence	Solution
…	…	…

Information/Capacity

Barrier	Consequence	Solution
…	…	…

https://www.esmap.org/sites/default/files/esmap-files/FINAL_EECI-WWU_TR001-12_Resized.pdf

3. Activity

On three tables, discuss consequences and possible solutions on the **following barriers**: regulatory/institutional; economic; information/capacity

Regulatory/Institutional	Economic	Information/Capacity
Politicised water/sewage tariffs	Low credit rating of water utilities	Inadequate management information about EE
Subsidised water/electricity	Small size of EE investments (individual EE measures)	Lack of knowledgeable operators doing EE
Budgeting structure constraints	Underdeveloped EE financing market	
Roles and responsibilities of operational staff and procurement within the utility is fixed	Expensive EE technologies	

https://www.esmap.org/sites/default/files/esmap-files/FINAL_EECI-WWU_TR001-12_Resized.pdf

3. Activity

ACTIVITY

(feel free to add additional barriers based on your experience)

https://www.esmap.org/sites/default/files/esmap-files/FINAL_EECI-WWU_TR001-12_Resized.pdf

3. Activity

Potential answers

Regulatory/Institutional		
Barrier	**Consequence**	**Solution**
Politicised water/sewage tariffs	Lack of revenue, affecting revenue and subsequent capability to invest in EE improvements	Sectoral reform: increase financial sustainability as a priority along with social concerns on water
Subsidised electricity	Lack of revenue, affecting revenue and subsequent capability to invest in EE improvements	Subsidy reforms / sectoral reform
Budgeting structure constraints	Reliance on operating cost from municipality reduces incentive to invest in EE improvements	Sectoral reform: increase independence of utility to reduce reliance on municipality
Roles and responsibilities of operational staff and procurement within the utility is fixed	Lack of system-wide understanding and hence decisions regarding energy	Establish energy management team which has a mandate to control energy cost

https://www.esmap.org/sites/default/files/esmap-files/FINAL_EECI-WWU_TR001-12_Resized.pdf

3. Activity

Potential answers

Economic		
Barrier	**Consequence**	**Solution**
Low credit rating of water utilities	Difficult to access EE for investment	Part of national effort to increase EE policy framework, energy services and financing opportunities - Reduce risks through guarantee facilities - Bundling through 3rd party arrangements like ESCOs - Dedicated fund/credit lines - Tax credits for EE equipment (**check colleagues at AE)**
Small size of EE investments (individual EE measures)	Difficult to gain commercial bank attention for smaller loans	
Underdeveloped EE financing market	Many financially attractive EE investments cannot be implemented	
Expensive EE technologies	Difficult to justify practicality of purchase	Bulk purchasing could reduce price of supply

https://www.esmap.org/sites/default/files/esmap-files/FINAL_EECI-WWU_TR001-12_Resized.pdf

3. Activity

Potential answers

Information/Capacity		
Barrier	**Consequence**	**Solution**
Inadequate management/government information about EE	Lack of interest to support EE interventions	• Develop and disseminate case studies and good practices • Develop centralized platforms for knowledge sharing • Develop benchmarking and assessment tools to guide decision making • Awards and recognition
Lack of knowledgeable operators doing EE	Inability to identify energy saving opportunities	• Conduct training and peer-to-peer learning • Learning energy efficiency networks (**Check Industry stream colleagues)**

https://www.esmap.org/sites/default/files/esmap-files/FINAL_EECI-WWU_TR001-12_Resized.pdf

Resources

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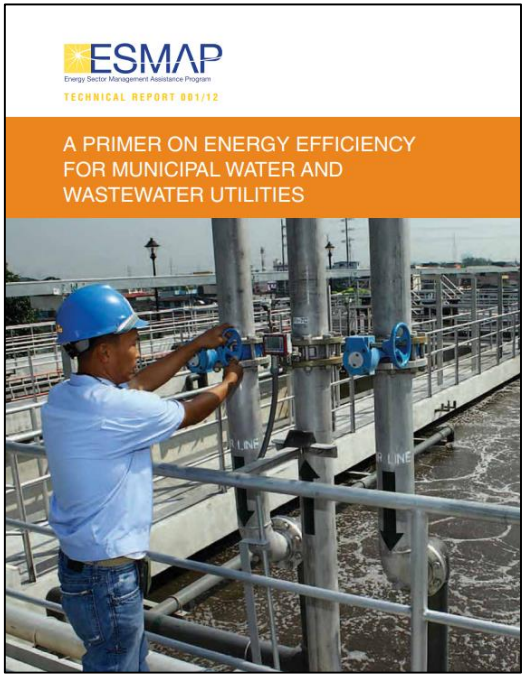
Resources

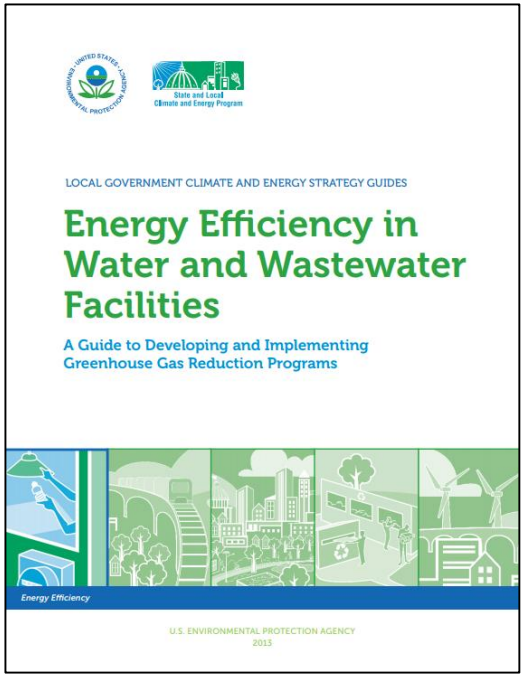
WORLD BANK GROUP

ESMAP

Energy Sector Management Assistance Program



https://www.esmap.org/sites/default/files/esmap-files/FINAL_EECI-WWU_TR001-12_Resized.pdf



https://www.epa.gov/sites/production/files/2015-08/documents/wastewater-guide.pdf

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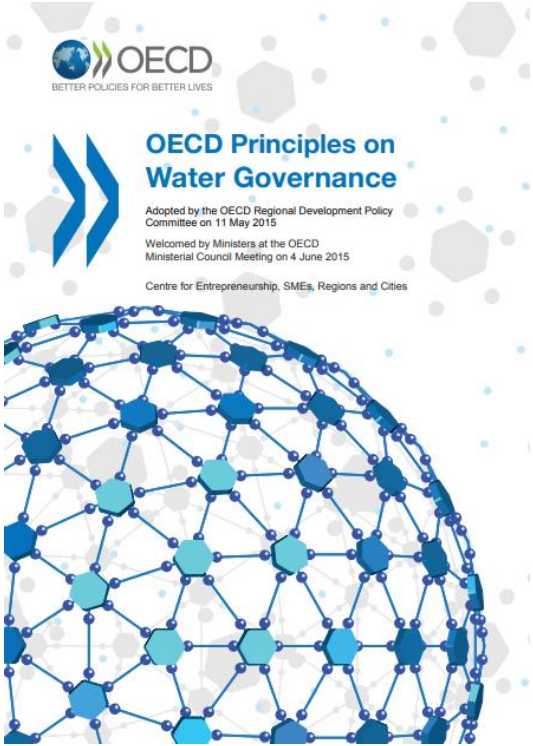
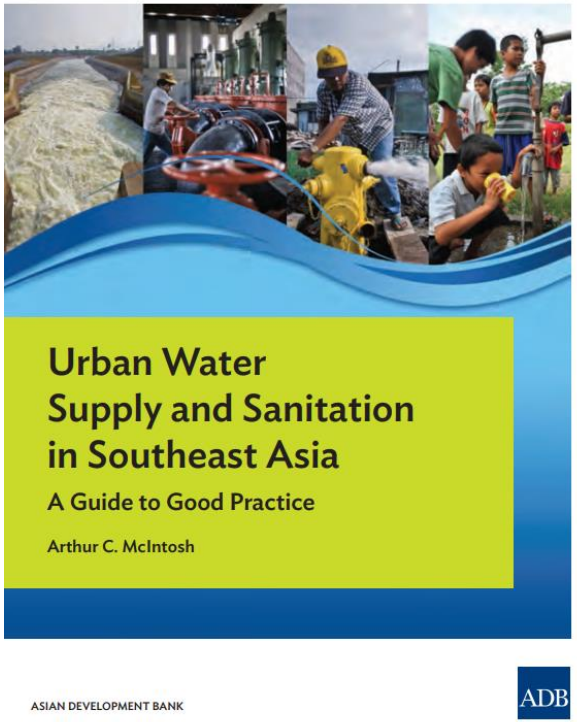


http://www.oecd.org/cfe/regional-policy/OECD-Principles-on-Water-Governance.pdf



https://www.pseau.org/outils/ouvrages/adb_urban_water_supply_and_sanitation_in_southeast_asia_a_guide_to_good_practice_2014.pdf

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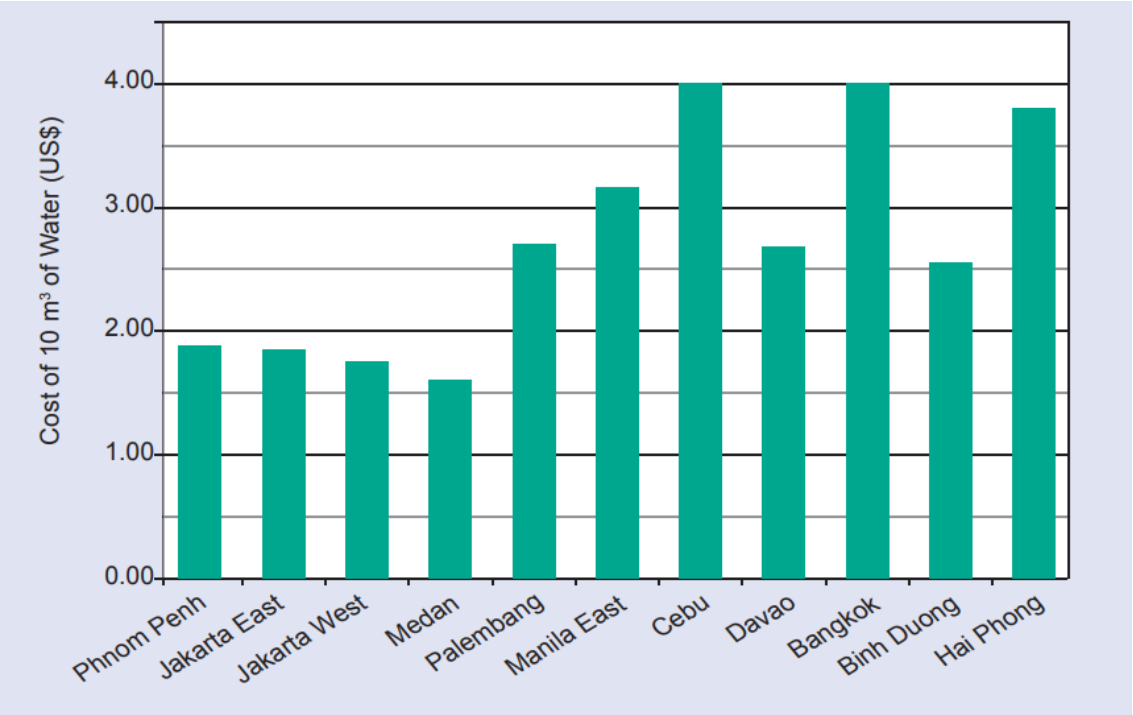
Additional slides

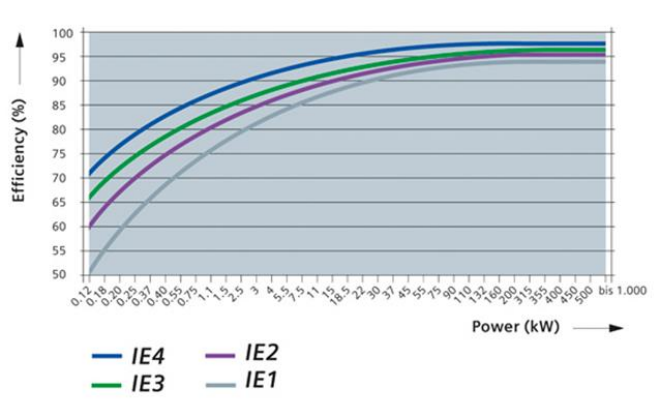
Energy use in water: Context in Southeast Asia

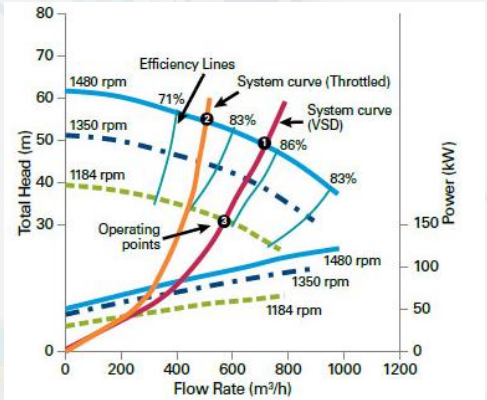


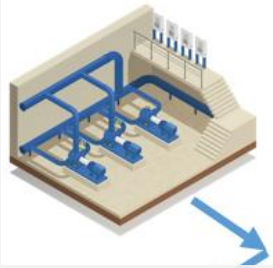
In Southeast Asia, cost is high but often, the quality does not match the price

Source: https://www.pseau.org/outils/ouvrages/adb_urban_water_supply_and_sanitation_in_southeast_asia_a_guide_to_good_practice_2014.pdf

Energy use in water: Drivers - Pumping







Pumping

Source http://www.gozuk.com/applications/vfd-for-pumps.html

Source https://w3.siemens.com/drives/global/en/motor/low-voltage-motor/efficiency-standards

Pump motors run almost non-stop. Improperly sized pumps or inefficient motors result to higher energy cost. Technologies like VFD ensure high efficiency even with varying demand

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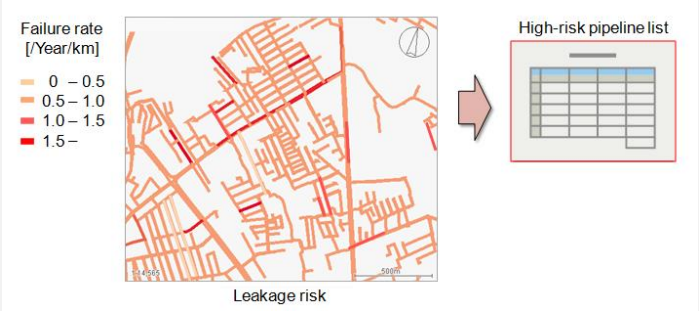
Strategies for energy efficiency. Reduce

Reduce Energy use

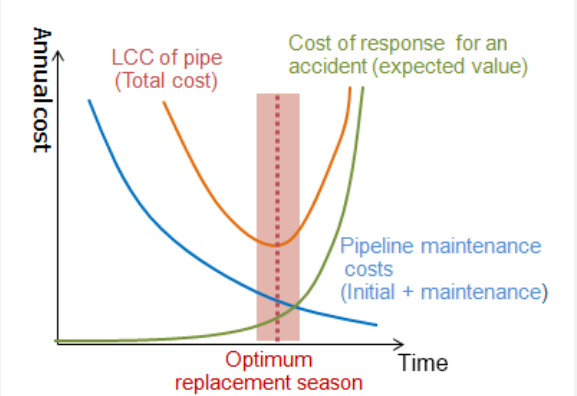
- **Energy management systems**
- Improve motor efficiencies
- Improve controls

- Example: Leak management system allowing preventive maintenance and timing of replacement

Preventive maintenance



Timing of replacement



Source https://www.viavisolutions.com/en-us/products/seeker-d-mca-iii

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