



5. Utilities: Water Management

Mel Slade

Paris, 22 May 2019



IEA #energyefficientworld

5. Utilities: Water Management

Trainer(s): Mel Slade

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?

5. Utilities: Water and Sewage

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**

4. **What are the steps?**

10 mins

10 mins

30 mins

15 mins

1. Energy use in water

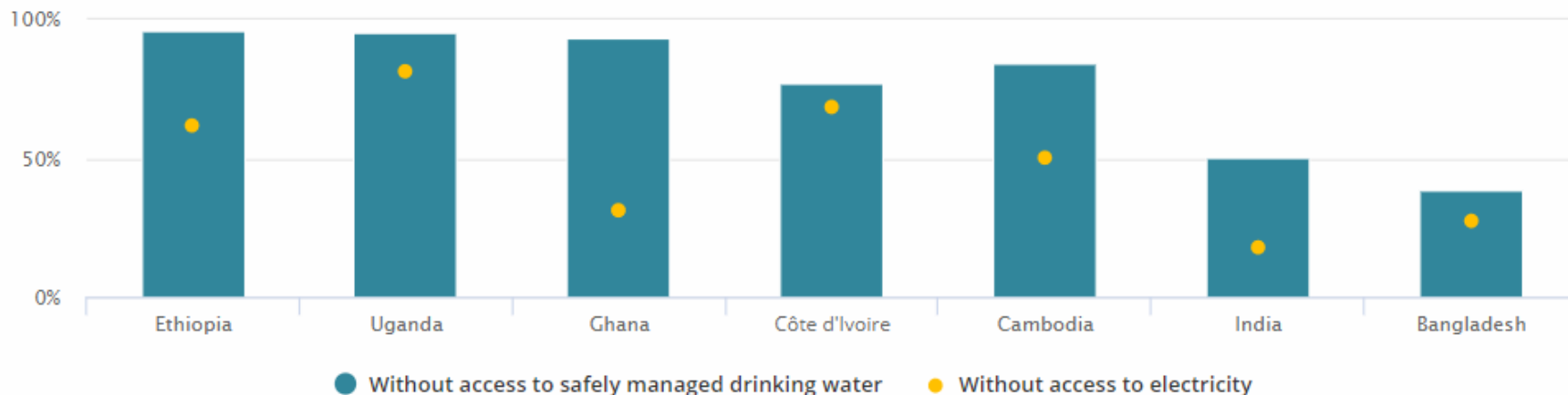
1. Energy use in water: Context

Where to start?

Tools

What are the steps?

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

1. Energy use in water: Context

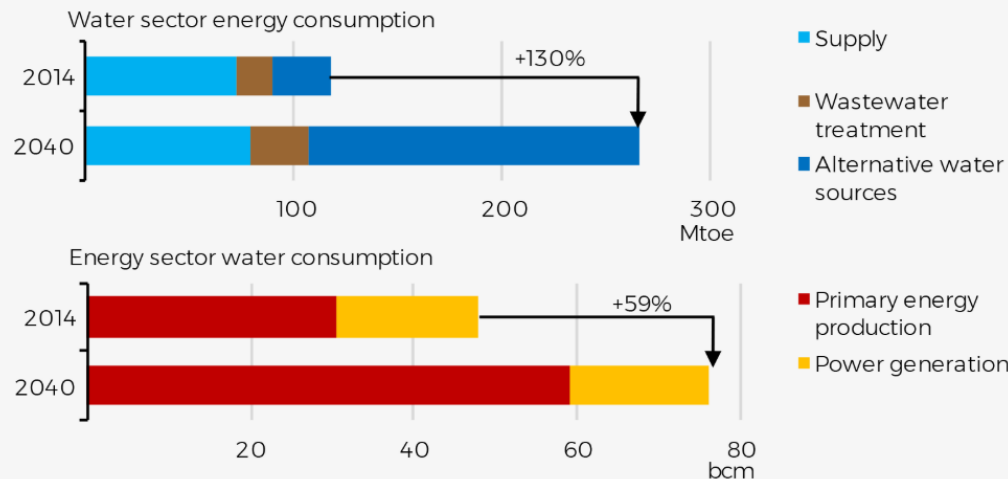
Where to start?

Tools

What are the steps?

Energy and water sector consumption

World Energy Outlook 2016



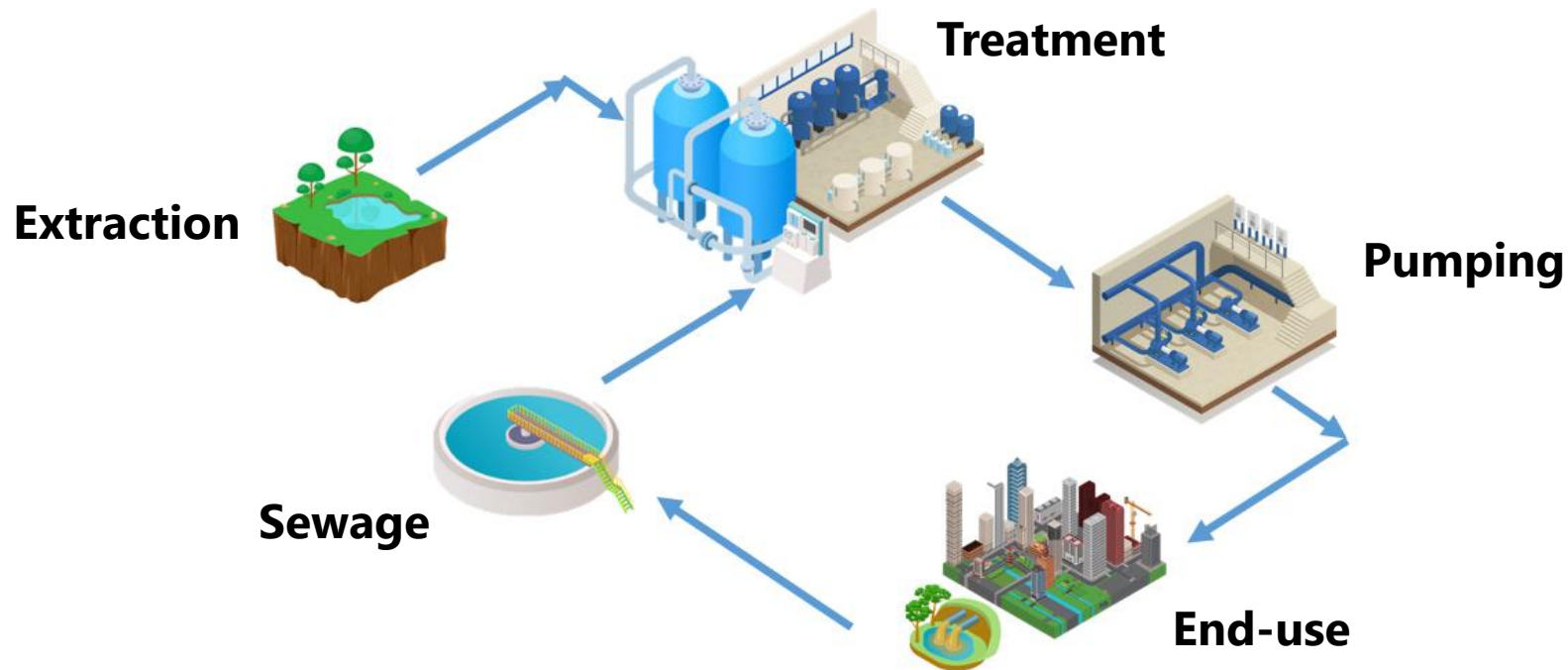
Energy is needed to obtain, process, and distribute water and water is also needed to keep energy services running. Energy efficiency is hence, important to provide both services

1. Energy use in water: Drivers

Where to start?

Tools

What are the steps?



1. Energy use in water: Drivers - Extraction

Where to start?

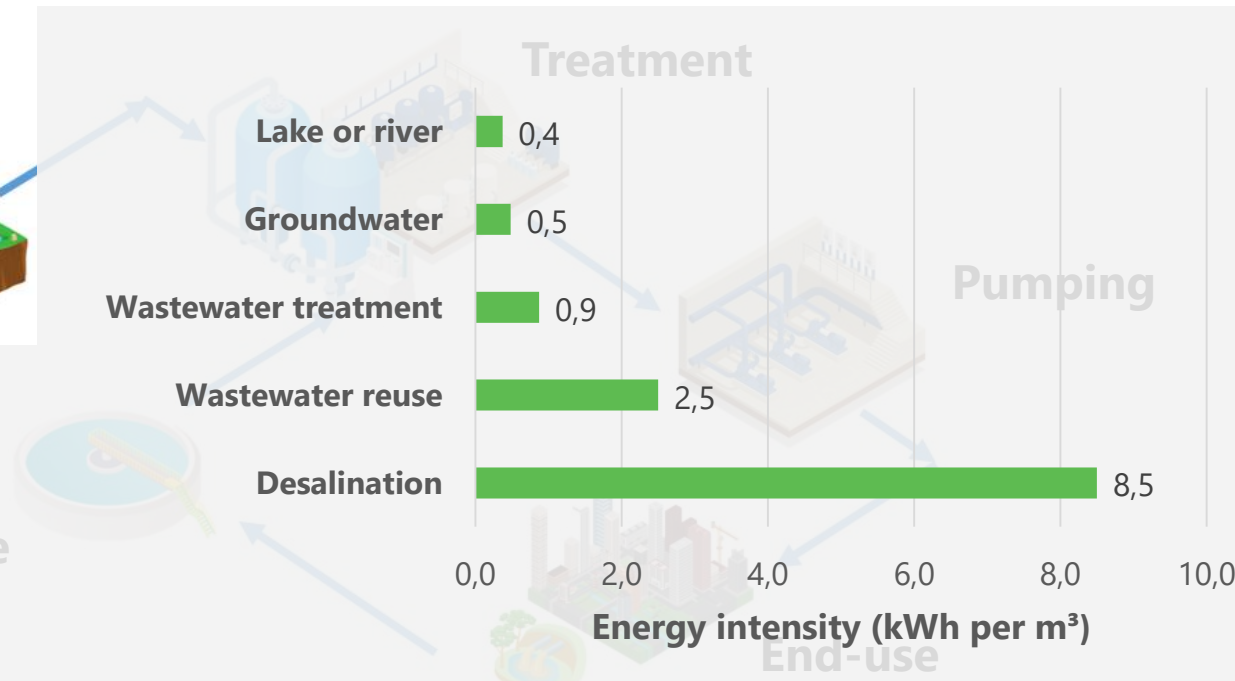
Tools

What are the steps?

Extraction



Sewage



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

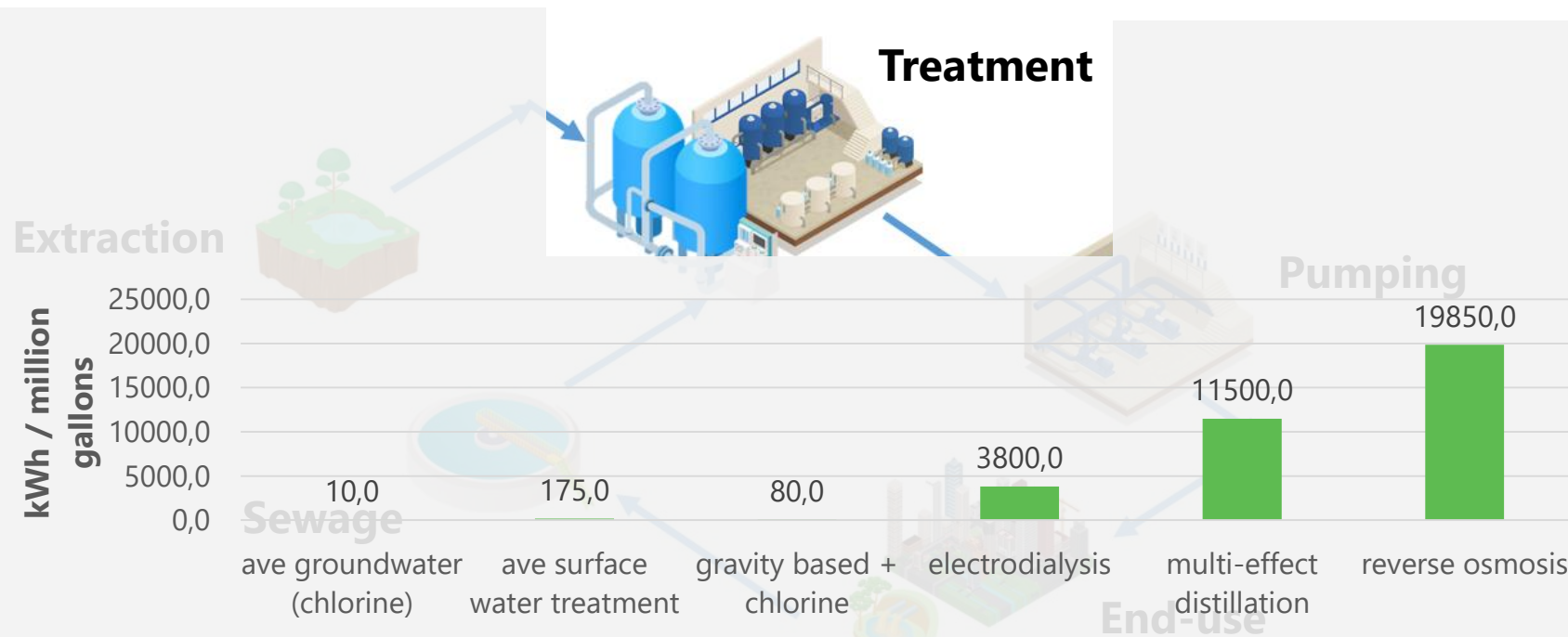
Source and location of water for extraction dictate the complexity of treatment and add extra energy use

1. Energy use in water: Drivers - Treatment

Where to start?

Tools

What are the steps?



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

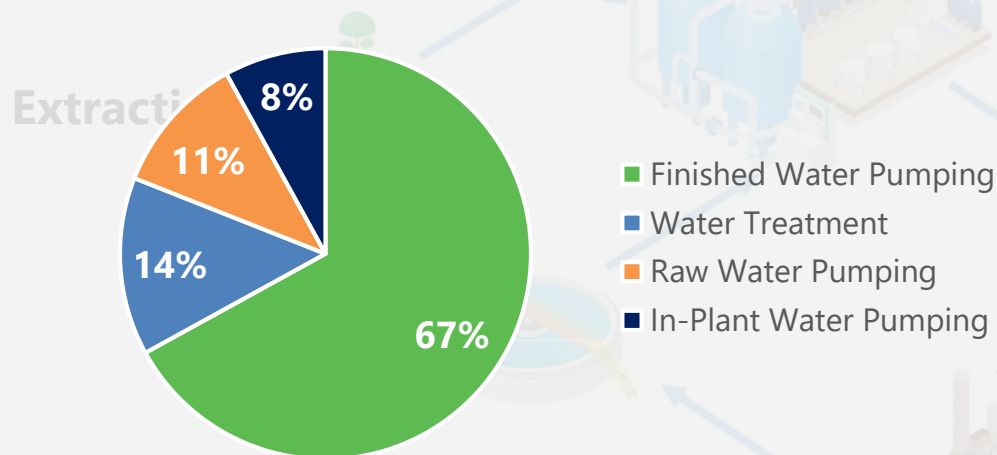
1. Energy use in water: Drivers - Pumping

Where to start?

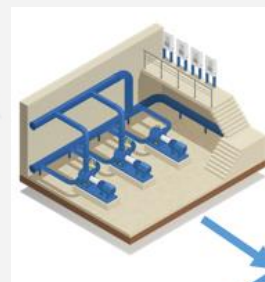
Tools

What are the steps?

Energy Costs in Water Supply



Treatment



Pumping

End-use

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

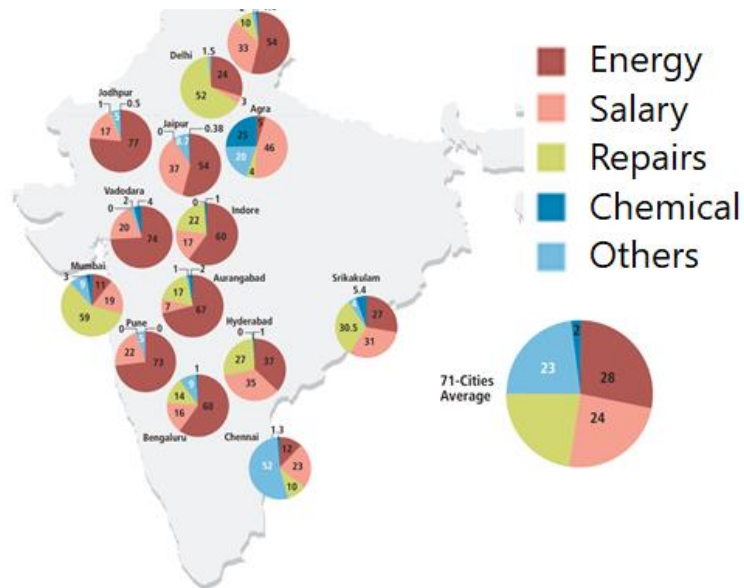
1. Energy use in water: Drivers - Distribution and end-use

Where to start?

Tools

What are the steps?

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

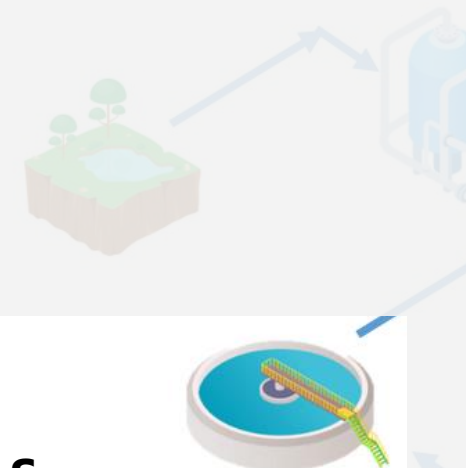
1. Energy use in water: Drivers - Sewage treatment

Where to start?

Tools

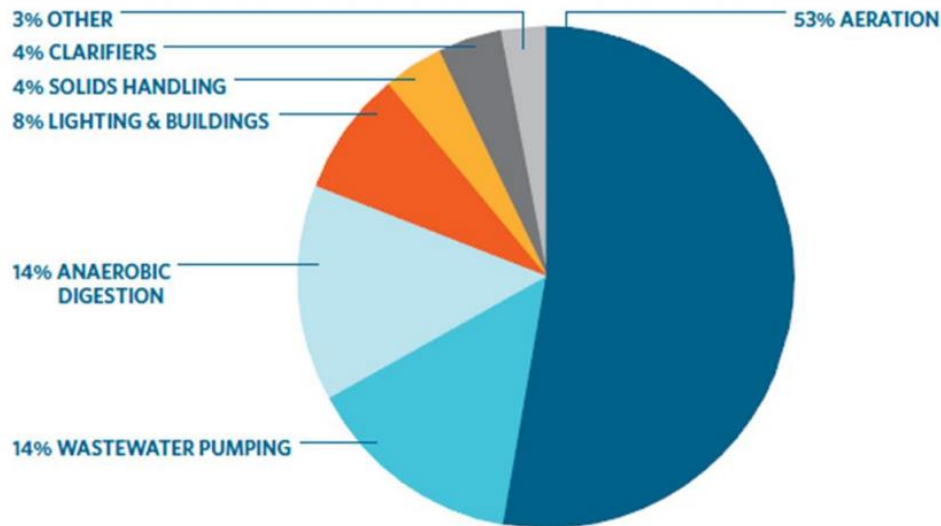
What are the steps?

Extraction



Sewage

Energy Costs in Wastewater



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

2. Tools: Strategies for energy efficiency

2. Tools: Strategies for energy efficiency

Where to start?

Tools

What are the steps?

Reduce Energy use



Recover Energy



Time Energy use

- Energy management systems
- Improve motor efficiencies
- Improve controls

- Anaerobic biodigestion of sewage to recover energy

- Stagger activities towards off-peak hours

2. Tools: Strategies for energy efficiency. Reduce



Where to start?

Tools

What are the steps?

Reduce Energy use

- **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



Where to start?

Tools

What are the steps?

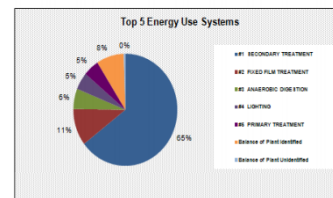
Reduce Energy use

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

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

Specify Other Utility Type (if any) Propane GAL					
Specify Units for Other Energy Consumption (if any)					
2011	Electric (\$/kWh)	\$0.1018	Natural Gas (\$/CCF)	\$1.1504	
2011	January	February	March	April	
Electricity Cost (\$) 2011	\$18,884.32	\$19,432.46	\$19,247.76	\$19,704.96	
Consumption (kWh) 2011	186,800	193,800	167,600	192,800	
Natural Gas Cost (\$) 2011	\$6,146.54	\$5,556.68	\$5,095.30		
Consumption (CCF) 2011	5,276	4,782	4,331		
No. 2 Fuel Oil Cost (\$) 2011	\$16,210.03	\$11,666.71	\$6,587.05		
Consumption (CCF) 2011	14,260	10,279	5,478	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	2,307,257	2,307,257	
Alternative Energy Cost (\$) 2011	\$1,014.30	\$2,235.80	\$2,571.40	\$2,394.60	
Consumption (CCF) 2011	1,473,000	1,566,000	1,578,000	1,642,000	
Other - Propane Cost (\$) 2011	\$1,070.30	\$1,535.60	\$2,324.30	\$3,080.10	
Consumption (GAL) 2011	975,000	1,396,000	2,103,000	2,691,000	
Total Utility Cost 2011	\$55,867.15	\$52,307.21	\$49,467.63	\$45,391.1	
Treatment Volume (MGAL) 2011	112,240	107,500	116,700	118,400	
Utility Cost/Treatment Volume (\$/MGAL)	\$497.75	\$484.72	\$424.06	\$383.1	
Electric Utilization (kWh/MGAL) 2011	1,753.39	1,765.58	1,607.64	1,620.1	

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	64.62%	1,452,103	\$146,953
#2 FIXED FILM TREATMENT	10.62%	238,639	\$24,150
#3 ANAEROBIC DIGESTION	5.98%	132,289	\$13,388
#4 LIGHTING	4.99%	111,865	\$11,321
#5 PRIMARY TREATMENT	4.99%	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 Wt 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 Recirc 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>

2. Tools: Strategies for energy efficiency. Reduce

Where to start?

Tools

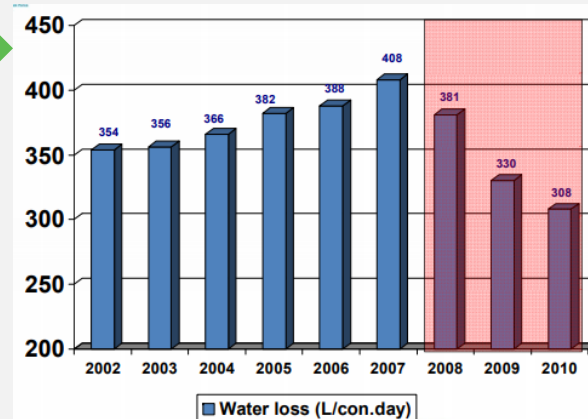
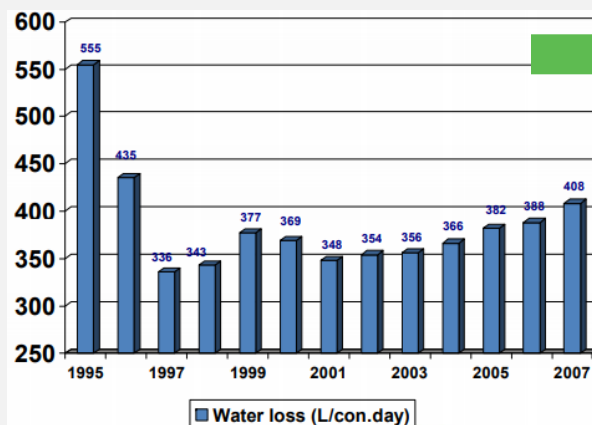
What are the steps?

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



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

2. Tools: Strategies for energy efficiency. Reduce

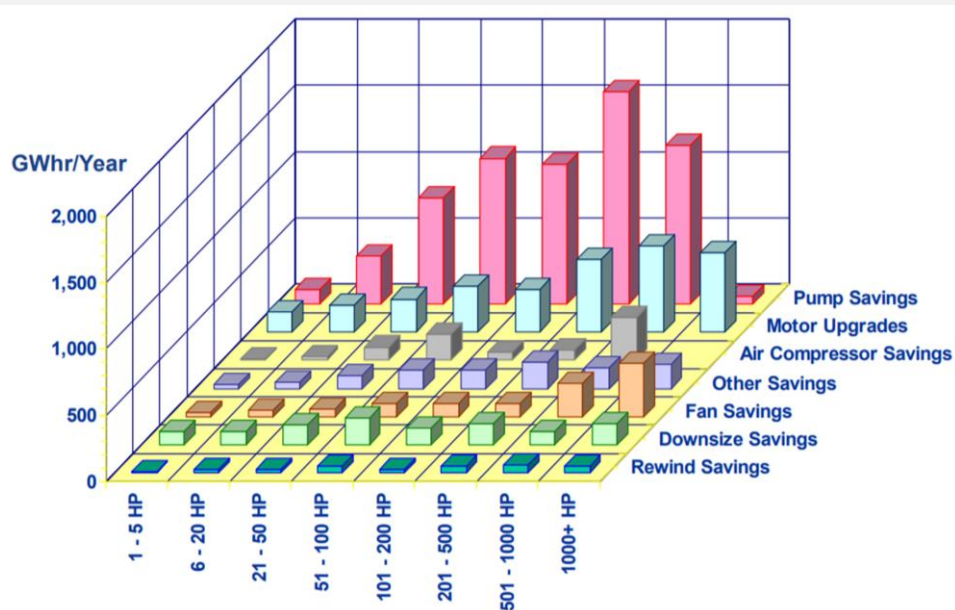
Where to start?

Tools

What are the steps?

Reduce Energy use

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



Source <https://betterbuildingssolutioncenter.energy.gov>

2. Tools: Strategies for energy efficiency. Reduce

Where to start?

Tools

What are the steps?

Reduce Energy use

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

**50% reduction
in electricity**



**2.14
GWh/year
savings
=
126 homes**

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

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

2. Tools: Strategies for energy efficiency. Reduce

Where to start?

Tools

What are the steps?

Reduce Energy use

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

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

**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>

2. Tools: Strategies for energy efficiency. Reduce

Where to start?

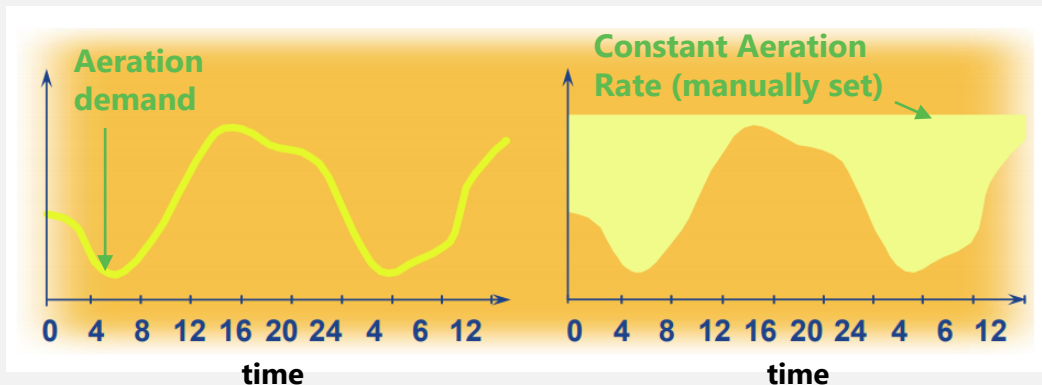
Tools

What are the steps?

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>

2. Tools: Strategies for energy efficiency. Recover



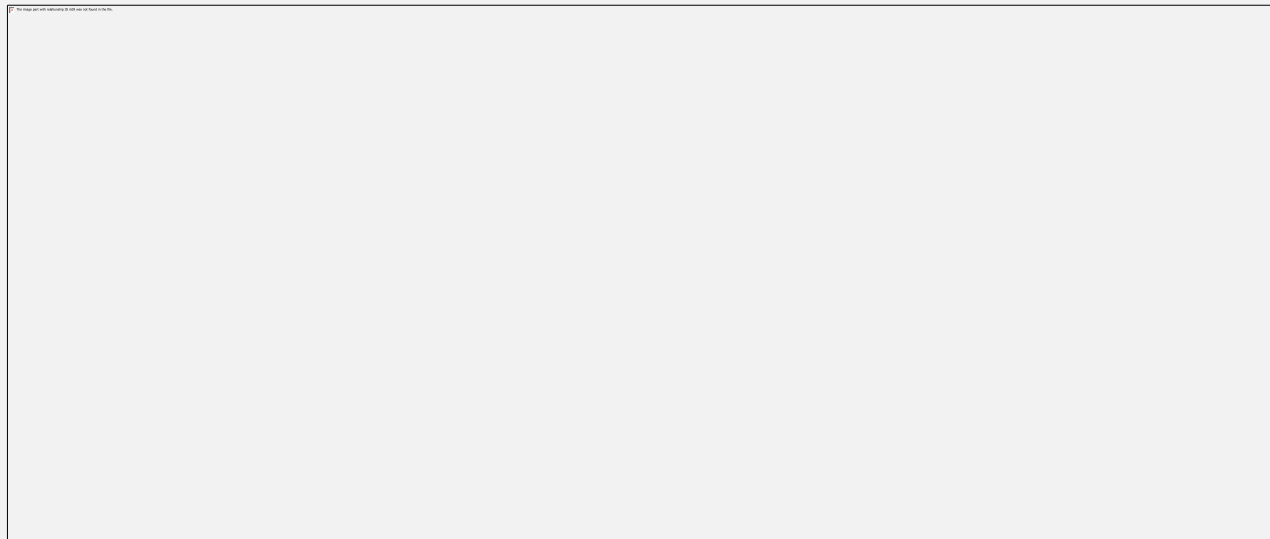
Where to start?

Tools

What are the steps?

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



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

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

2. Tools: Strategies for energy efficiency. Time

Where to start?

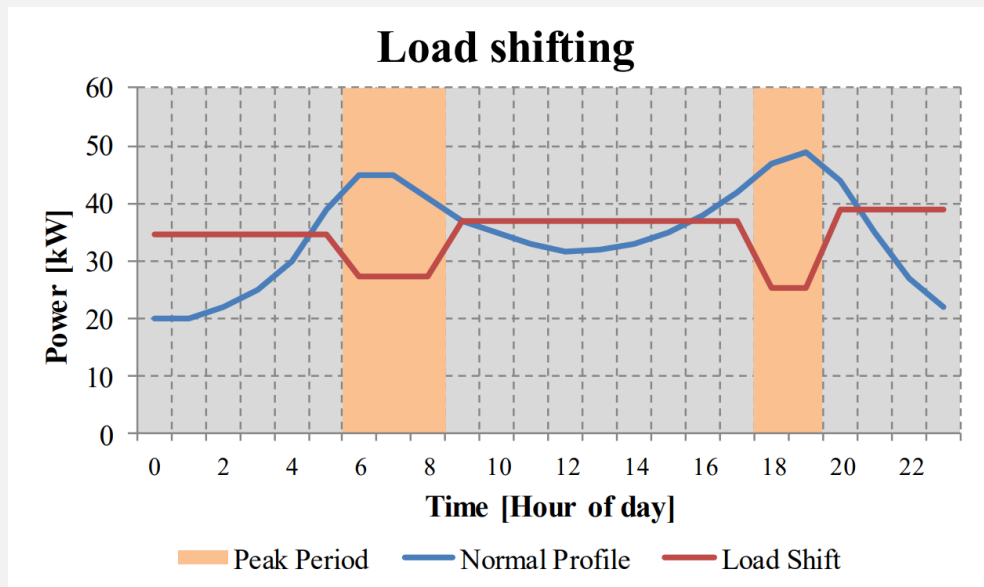
Tools

What are the steps?

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

2. Tools: Strategies for energy efficiency. Time

Where to start?

Tools

What are the steps?

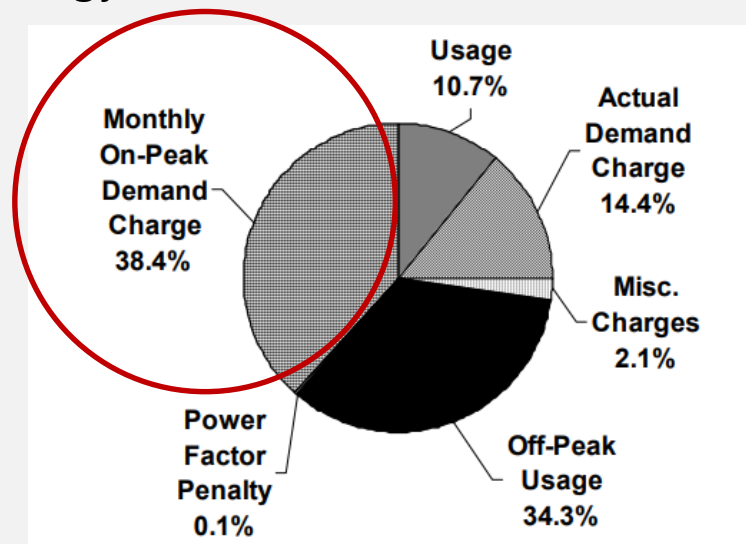
Time Energy use

- **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>

2. Tools: Strategies for energy efficiency. Other Strategies



Where to start?

Tools

What are the steps?

- **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

Where to start?

Tools

What are the steps?

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
...

3. Activity

Where to start?

Tools

What are the steps?

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	

Where to start?

Tools

What are the steps?

ACTIVITY

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

3. Activity

Where to start?

Tools

What are the steps?

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

3. Activity

Where to start?

Tools

What are the steps?

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 <ul style="list-style-type: none"> - 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

3. Activity

Where to start?

Tools

What are the steps?

Potential answers

Information/Capacity

Barrier	Consequence	Solution
Inadequate management/government information about EE	Lack of interest to support EE interventions	<ul style="list-style-type: none">• 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	<ul style="list-style-type: none">• Conduct training and peer-to-peer learning• Learning energy efficiency networks (Check Industry stream colleagues)

4. What are the steps?



4. What are the steps?

Plan

Step 1. Get Ready

- Establish the facility's energy policy and overall energy improvement goals
- Secure and maintain management commitment, involvement and visibility
- Choose an energy "fenceline"
- Establish energy improvement program leadership
- Secure and maintain employee and management buy-in

Step 2. Assess Current Energy Baseline Status

- Establish a baseline and benchmark facilities
- Perform an energy audit
- Identify activities and operations that consume the most energy or are inefficient

Step 3. Establish an Energy Vision and Priorities for Improvement

- Identify, evaluate, and prioritize potential energy improvement projects and activities

Step 4. Identify Energy Objectives and Targets

- Establish energy objectives and targets for priority improvement areas
- Define performance indicators

4. What are the steps?

Do

Step 5. Implement Energy Improvement Programs and Build a Management System to Support Them

- Develop action plans to implement energy improvements
- Get top management's commitment and approval
- Develop management system "operating controls" to support energy improvements
- Begin implementation once approvals and systems are in place

Check

Step 6. Monitor and Measure Results of the Energy Improvement Management Program

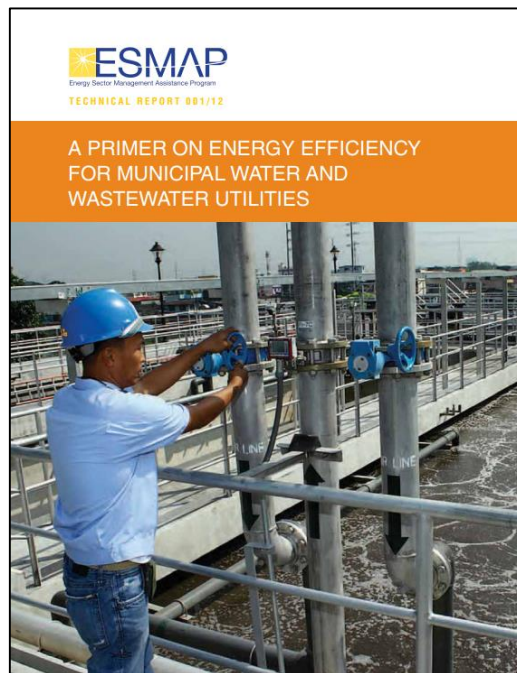
- Review what the facility currently monitors and measures to track energy use
- Determine what else the facility needs to monitor and measure its priority energy improvement operations
- Develop a plan for maintaining the efficiency of energy equipment
- Review the facility's progress toward energy targets
- Take corrective action or make adjustment when the facility is not progressing toward its energy goals
- Monitor/reassess compliance status

4. What are the steps?

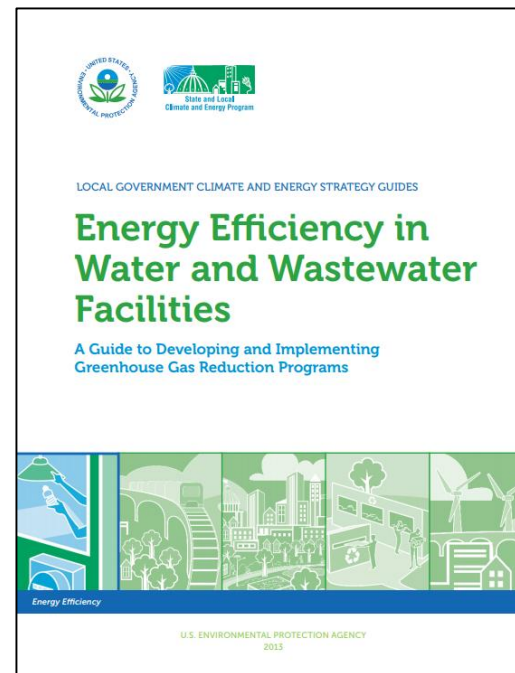
Act

Step 7. Maintain the Energy Improvement Program

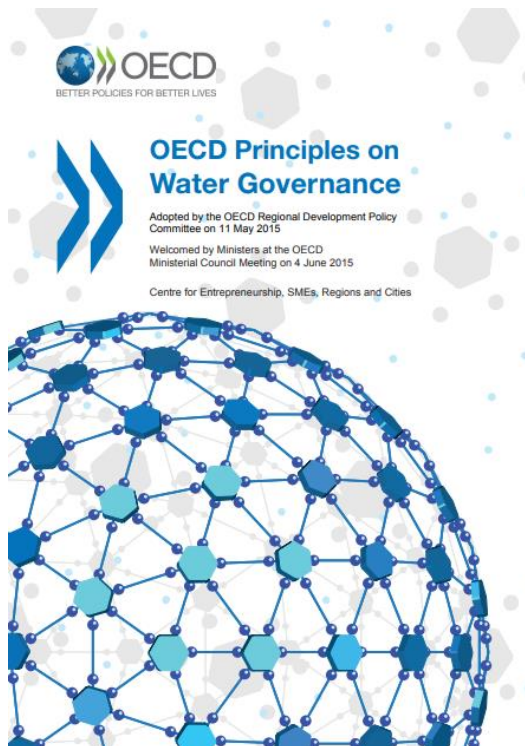
- Continually align energy goals with business/operation goals
- Apply lessons learned
- Expand involvement of management and staff
- Communicate success



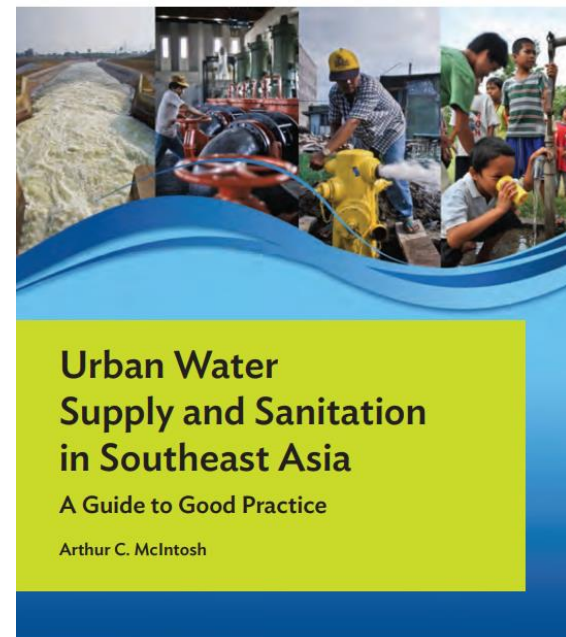
https://www.esmap.org/sites/default/files/esmap-files/FINAL_EECI-WWU_TR001-12_Resized.pdf



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



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



ASIAN DEVELOPMENT BANK



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



www.iea.org



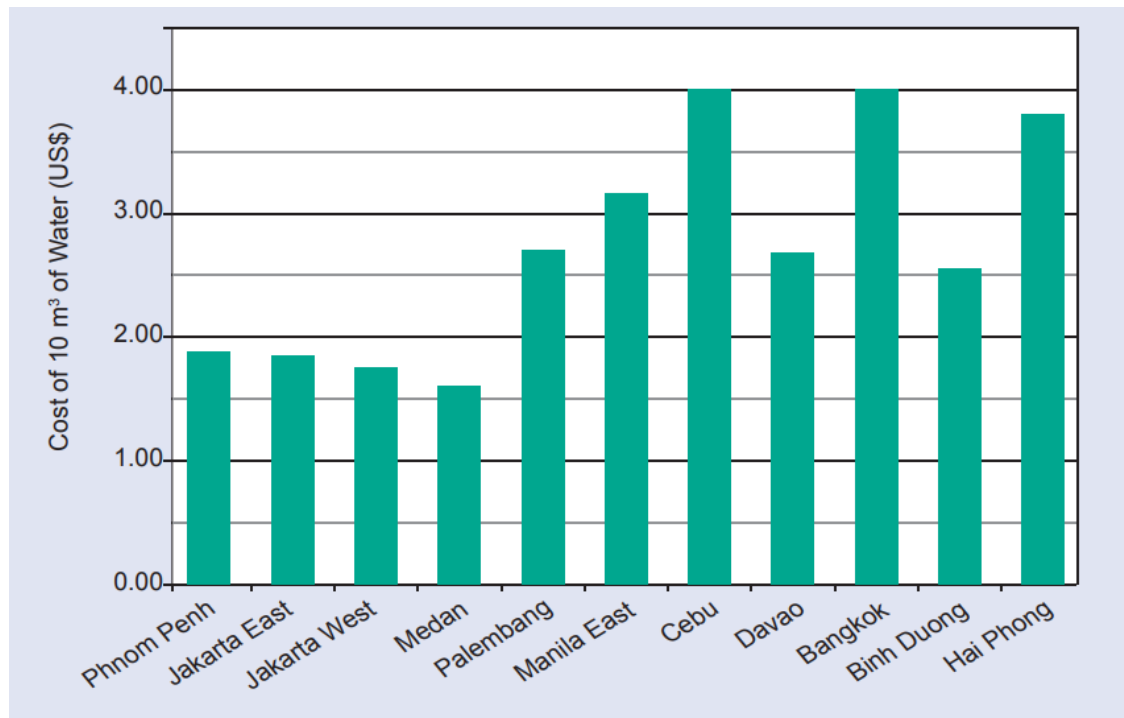
IEA #energyefficientworld

Energy use in water: Context in Southeast Asia

Where to start?

Tools

What are the steps?

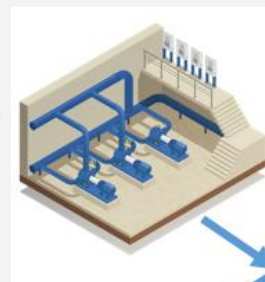
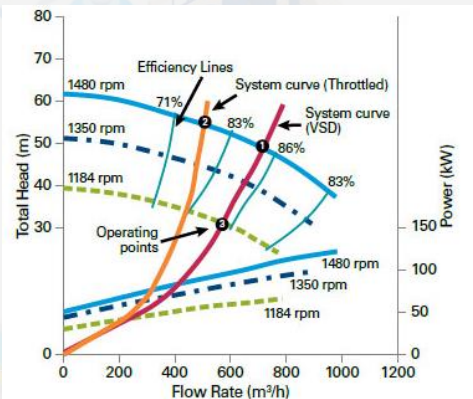
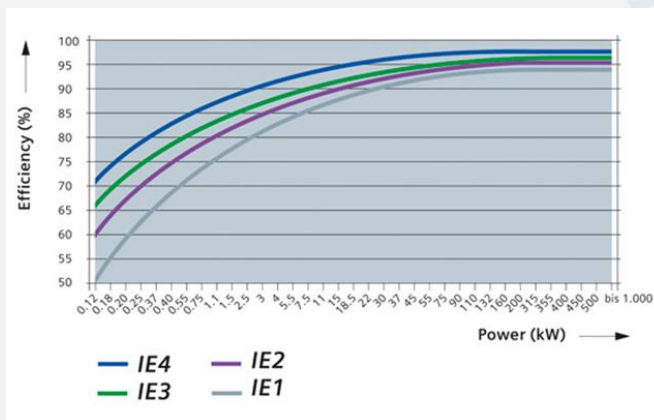


In Southeast Asia, cost is high but often, the quality does not match the price

Where to start?

Tools

What are the steps?



Pumping

Sewage

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

Reduce Energy use

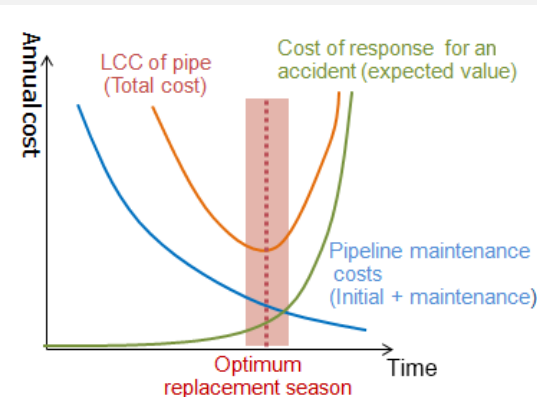
- Example: Leak management system allowing preventive maintenance and timing of replacement

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

Preventive maintenance



Timing of replacement



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



www.iea.org



IEA #energyefficientworld