Implications of Falling Usage for Water Utilities

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But first... where does it rain more, Dallas or Detroit?
Trends in usage: electricity

Electricity generation in the U.S. (EIA 2012)

- Total electricity generation (bkw/h)
- Electricity generation per capita
- Electricity generation per GDP ($2005 bil.)
Trends in usage: natural gas
Trends in usage: water

Total water withdrawals in the U.S. (USGS, EIA)
The headline: “growing water demand”
The reality: “slowing water demand”

- Dramatic efficiency gains appear durable without loss of technical functionality
- Usage remains stable even in the context of macroeconomic growth
- Water appears to defy “Jevons paradox” for resource consumption
Water resources globally and in the U.S.

- Water is a renewable resource but also transient and vulnerable
- The U.S. is relatively water abundant but resource stress is apparent

Freshwater withdrawals in the U.S. by sector
Freshwater withdrawals in the U.S. by sector

- **Thermoelectric power:** 41%
- **Irrigation:** 37%
- **Public supply domestic:** 7%
- **Public supply nondomestic:** 5%
- **Rural domestic:** 1%
- **Livestock:** 1%
- **Mining:** 1%
- **Aquaculture:** 2%
- **Industrial:** 5%

**Bar chart:**
- Saline
- Fresh

**Map:**
- United States

**Legend:**
- Blue = saline
- Green = fresh
- White = mixed
- Black = public supply
- Gray = irrigation
High-capacity wells (Wisconsin)

- Irrigators are digging the high-capacity wells
Water usage in U.S. cities (WRF, 2011)

Water usage in western U.S. cities

Sources: Denver Water, Aurora Water, Seattle Public Utilities, Eugene Water and Electric Board, Phoenix Water Service, Tucson Water
Dallas water consumption trend (1996-2011)
Detroit daily water pumpage (2009-2014)
Detroit water sales and non-revenue water

Detroit sales and non-revenue water (%)

Detroit sales and non-revenue water
Change in population and pumpage for Michigan cities

Michigan cities: 2000 to 2010* (sorted by average-day demand)

- Change in population
- Change in average-day
- Change in maximum-day

Traverse City, Ann Arbor, Muskegon, Grand Rapids, Holland, Pontiac, Saginaw, Flint (*2001-10)
Max-day to average-day pumpage trends
Michigan water rates (largest cities)
Traverse City

![Graph showing water pumped (MGD) and population trends from 2000 to 2011. The graph indicates fluctuations in water pumped with a peak in 2007 and a decline afterwards. The population remains relatively constant throughout the period.]
Ann Arbor
Muskegon
Grand Rapids

Grand Rapids

Water pumped (MGD)

Max-day MGD

Average-day MGD

Population


Beecher Water MI 2014
Holland

![Graph showing water pumped (MGD) and population trends over time in Holland. The graph indicates a decrease in water pumped and an increase in the number of residents from 1998 to 2011. The data suggests a reduction in water use per capita.](image-url)
Pontiac
Saginaw
Flint

Flint

- Max-day MGD
- Average-day MGD
- Population

Water pumped (MGD)

Population


0 10 20 30 40 50 60

10,000 20,000 30,000 40,000 50,000 60,000 70,000 80,000 90,000 100,000 110,000 120,000 140,000
Falling water usage

- Aggregate, per-connection, and per-capita water use is stable or falling
- Declining annual sales of 1-3% are not uncommon (25% cumulative per WRF)
- This nonlinear trend may reach an equilibrium in perhaps 10-15 years (?)
- Population and economic activity remain significant local drivers
- Persistent usage volatility is associated with climate and weather
- Developing economies still see growth while legacy cities see decline
Apparent causes for falling water usage in the U.S.

- **Per-connection or per household**
  - Demographic shifts (population, household size)
  - Property (lot) size and growth policies
  - Nature of commercial and industrial activities
  - Irrigation efficiency (practices, codes, efficiencies)
  - Aging water meters that under-register (minor role)
  - Effects of recession on economy and income (temporary?)
  - Cost and price effects on discretionary use (elasticity)

- **Per-capita or per-function**
  - Efficiency standards (EPAct 1992), codes, and ordinances
  - Commercial and industrial processes an technologies
  - Changing culture and environmental ethic (e.g., lawn watering)

- **No new offsetting uses for potable water**
  - Except for hydraulic fracturing – unregulated (by EPA) and may count as mining (by USGS)
  - Compare to energy
The added challenge for legacy cities

- Shrinking customer base and economic activity
- Excess capacity and stranded investment
- Aging infrastructure and water losses
- Rising costs and water prices
- Persistent income disparity and unemployment
- Limits to “growing our way out”
Household expenditures on utilities over time
Utilities expenditures by income level and regressivity

Consumer expenditures on utilities by income quintile (all consumers $2012)

Consumer expenditures on utilities by income quintile (all consumers 2012%)

- Water and other public services
- Fuel oil and other fuels
- Natural gas
- Telephone
- Electricity

- Lowest quintile:
  - 1.33% Water and other public services
  - 0.32% Fuel oil and other fuels
  - 0.91% Natural gas
  - 2.95% Telephone
  - 4.32% Electricity

- 2nd quintile:
  - 1.25% Water and other public services
  - 0.32% Fuel oil and other fuels
  - 0.84% Natural gas
  - 2.99% Telephone
  - 3.73% Electricity

- 3rd quintile:
  - 1.17% Water and other public services
  - 0.27% Fuel oil and other fuels
  - 0.77% Natural gas
  - 2.88% Telephone
  - 3.19% Electricity

- 4th quintile:
  - 1.01% Water and other public services
  - 0.25% Fuel oil and other fuels
  - 0.69% Natural gas
  - 2.51% Telephone
  - 2.53% Electricity

- Highest quintile:
  - 0.82% Water and other public services
  - 0.25% Fuel oil and other fuels
  - 0.58% Natural gas
  - 1.83% Telephone
  - 1.89% Electricity
CPI trends for utilities (U.S.) with forecast
Why water prices may matter more today

- Water rates are rising much faster than inflation generally or for other utilities
- Water usage is relatively price inelastic but not perfectly so
- Discretionary use (nonresidential and outdoor residential) is more price-elastic (responsive)
- Could be entering a more price-elastic segment of the demand curve
- Emerging evidence suggests responsiveness to marginal prices as well as to the total bill
- Well-designed prices (increasing block, seasonal rates) can help close the peak-to-average ratio

Fig. 1. Estimated price elasticities and ranges at different marginal prices
Usage trends by class (Lansing BWL)
Benefits of end-use efficiency

- Efficiency lowers costs and revenue requirements (“nega-gallons”)
  - Short-run: avoid variable operating inputs – *including energy*
  - Long-run: extend asset life and resize, postpone, or avoid new capacity

- Efficiency improves water system operation and management
  - Prudent capacity utilization through reductions of peak demand
  - Reduced revenue and earnings volatility (risk)

- Efficiency cannot avoid all system costs – particularly in the replacement cycle
  - Hyper-efficiency may have deleterious consequences for systems and customers

A note on hyper-efficiency for indoor usage

- Technological standards will continue to drive indoor usage down
  - Households are becoming much more efficient (<40 gpcd for indoor use)
  - Marginal value of conservation diminishes due to current operational requirements
  - Local conservation may have limited global impact (except for energy usage)
  - Attention should turn to outdoor use and other sectors (irrigation and cooling)

- Hyper-efficiency (<25 gpcd) has operational consequences
  - Low flows may cause water pressure and quality issues (need for flushing)
  - Low flows also affect wastewater operations (flushing, pressure, or vacuums)
  - Increased use of maintenance water may offset conservation savings
  - Indoor water can be captured as a resource for reusing and recharging
Demand and water system design

**Maximum-hour (hourly peak) demand**
- Max-day *plus* fire-flow requirements (codes, insurance)
- Treated water storage, distribution mains, pumping stations

**Maximum-day (daily peak) demand**
- Water treatment plants
- Major transmission lines

**Average-day demand**
- Source-of-supply facilities, including raw water storage, such as reservoirs
Efficiency and volatility

- Gross sales volatility is primarily a function of weather-sensitive outdoor use
  - Indoor usage is less responsive (elastic) relative to price and other changes
  - Rising variable prices and bills could drive down outdoor usage significantly

- Trends in indoor and outdoor usage determine the weather effect on water sales
  - Supply-side (leak control) and indoor efficiency will lower base-load usage, although only the latter will affect sales revenues

- Sales and revenue volatility remain a function of outdoor water usage
  - If maximum (outdoor) use persists or rises, volatility will increase due to the larger disparity between peak and off-peak usage
  - If maximum (outdoor) use falls, volatility will decrease due to narrowing of peak to off-peak
Outdoor usage drives demand and volatility (Lansing BWL)
Outdoor efficiency will reduce sales and revenue volatility.
The conservation conundrum: rates and revenues

- For most, cost of service is driven more by infrastructure than the commodity
  - Short-run marginal costs tend to be low given substantial fixed capacity

- In theory, other things equal, reduced water usage requires higher rates
  - Revenue neutrality suggests that bills would remain about constant – and actually be slightly less due to savings in variable costs

- In reality, water bills are going up not due to lower usage but due to higher costs
  - Total costs are rising for most systems due to infrastructure investment
  - Unit costs are rising for some systems due to loss of customers and scale economies

- Utilities have a difficult messaging problem with regard to higher water bills
  - Efficiency cannot promise lower bills, but it should promise “lower highs”
Sales, revenues, and rates (Wisconsin)
Revenue shortfalls for water utilities: key culprits

- **Lack of timely rate adjustments**
  - Utility and regulatory lag and rate politics (public systems)

- **Inadequate cost and demand forecasting**
  - Test year for ratemaking

- **Rate design**
  - Rate blocks and dependence on variable usage

- **Concurrent loss of other revenues**
  - Subsidies and fees
Rate revenue is a product of a numerator and denominator

\[
Rates = \frac{\text{Revenue requirements}}{\text{Sales}}
\]

- Test year, cost and revenue adjustments, and rates of return
- Forecasting, analysis, and demand modeling
Moving averages

- Moving averages may be inadequate for forecasting and ratemaking
- A high-volatility but stationary trend (lower line) may be easier to manage than a low-volatility but non-stationary trend (downward trending line)
- Revenues will always lag during a non-stationary downward trend
From passive to active forecasting (Seattle)

- Active forecasting considers various determinants (endogenous and exogenous)
- Statistically adjusted end-use modeling can be used
- More research is needed to lower forecasting costs and improve accuracy

- Geographic information systems (GIS) can be used to map demand
- Data and models can improve understanding of demographic patterns
Fixing revenues by fixed prices

- Water sector should resist the impulse to move toward fixed-variable pricing
  - In the long run, *all costs are variable* – and pricing should reflect this

- High fixed charges
  - Undermine affordability and equity, where low-use subsidizes high-use
  - Undermine price signals to promote efficient outdoor usage (perpetuates peaking)

- Revenue stability can be provided by well-designed block or seasonal rates
  - First blocks can provide considerable stability

- New variable pricing models may be needed
  - Use of peaking factors to improve cost allocation and rate design
  - Use of three-part tariffs (customer, capacity, commodity)
  - Use of property value to assign some fixed capacity costs
  - Dynamic pricing is less applicable to water due to storage (like natural gas)
Multi-objective water pricing

- Multi-objective rates can help achieve both equity and efficiency
  - Lifeline rate at lowest block for affordable access to meet basic needs
  - Graduated capacity charge based on property value (related to fire protection)
  - Increasing block rate based on usage to encourage efficiency
Long-term implications of a “new normal”

- Water demand could become more stable and predictable and should eventually find a new normal or new equilibrium (35-45 gpcd?)
  - The wild card remains outdoor use in relation to weather and climate but cultural efficiency gains there will change the water game

- Benefits of stable and efficient (“low”) water usage to utilities
  - Demand forecasting becomes easier
  - Weather and climate becomes less determinative
  - Rate design becomes less determinative
  - Customer bills (revenues per customer) flatten
  - Securing financial capital becomes easier
  - Hedging (for revenue instability) becomes unnecessary

- In other words, revenue stability can be achieved over time with sound pricing and increased end-use efficiency
Estimated infrastructure needs and funding “gaps”

- Estimates of infrastructure needs and funding gaps are not necessarily considering the effects of changing usage and opportunities to avoid costs.

**Total 20-Year Need by Project Type**
(in billions of January 2011 dollars)

- Total National Need $384.2 Billion
- Treatment $72.5 (64.4%)
- Source $20.5 (18.9%)
- Other $4.2 (5.3%), 1.1%
- Storage $39.5 (10.3%)

Transmission and Distribution $247.5

Note: Numbers may not total due to rounding.
Re-optimizing water and wastewater systems

- Don’t build tomorrow’s water systems to meet yesterday’s water demand
  - Failure to capture avoided costs in system design negates benefits of efficiency
  - Optimization includes all functions (production, distribution, storage, and energy management)
  - Public systems may underinvest while private systems may overinvest (AJ effect)
  - Both need to guard against risk of imprudent or stranded investment from “expansion”
  - Assumptions about replacement should be scrutinized and cost recovery should not be automated
  - Supply augmentation (desalination and gray-water systems) should be carefully evaluated

Water industry capital expenditures
(EPA, CWSS 2006)
Strategic infrastructure planning

- It may be imprudent to replace all pipes pre-emptively (Seattle)
- Some systems practice watchful “run-to-failure” for some infrastructure
- Water differs from natural gas on this issue for obvious safety reasons
System optimization modeling

- Water systems benefit from capital planning and asset management
- Advanced modeling can identify pipes to upsize, downsize, add, or abandon
- Genetic algorithm optimization model considers water and energy (Optimatics)
Water systems and fire protection

- Water systems are co-generators: one pipe delivers five products (20 tons/mo.)
- Indoor water use could become a byproduct of fire protection and sanitation
- How water is used has implications for rates and rate design

<table>
<thead>
<tr>
<th>Usage</th>
<th>Gallons/month (four-person household)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption: drinking and cooking</td>
<td>1,000</td>
</tr>
<tr>
<td>Personal hygiene: washing and sanitation</td>
<td>1,000</td>
</tr>
<tr>
<td>Home hygiene: laundry and cleaning</td>
<td>1,000</td>
</tr>
<tr>
<td>Discretionary: irrigation and other outdoor use</td>
<td>1,000 – 3,000</td>
</tr>
<tr>
<td>Fire protection</td>
<td>???</td>
</tr>
</tbody>
</table>
From growth to sustainability: a new paradigm

- **Sustainability means living within economic, ecological, equity tolerances**
  - Ecological constraints can be defined in terms of natural boundaries (watersheds)
    - Imports and exports, alternative technologies
  - Economic constraints can be defined in terms of financial boundaries
    - Pricing practices, subsidies, and taxes
  - Equity constraints can be defined in terms of political and institutional boundaries
    - Public policies (standards, permits, regulations, taxes)

- **Sustainable systems**
  - Spend to an optimal level of service
  - Price according to the cost of service

- **Sustainable systems reconcile multiple social goals**
  - Promoting public health, well-being, and development
  - Stewarding and managing water resources wisely for the long term
  - Reducing, reusing, recycling, and recharging
## Pricing and sustainability

<table>
<thead>
<tr>
<th>Price revenues relative to expenditures</th>
<th>Expenditures relative to optimal service level</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1 price revenues are below expenditures (“price avoidance”)</td>
<td>&lt; 1 expenditures are below optimum (“cost avoidance”)</td>
</tr>
<tr>
<td></td>
<td>Deficient system</td>
</tr>
<tr>
<td>= 1 price revenues are equal to expenditures</td>
<td>Underinvesting system</td>
</tr>
<tr>
<td>&gt; 1 price revenues are above expenditures (“profit seeking”)</td>
<td>Revenue-diverting system</td>
</tr>
</tbody>
</table>
Observations

- Demand may go very low as prices elasticities drive discretionary usage down
- Outdoor usage will drive sales and revenue volatility, particularly if underpriced
- Decline has occurred largely without programs, incentives, or “decoupling”
- There is significant potential to avoid operating and capital costs
- Water utilities need to invest in forecasting, modeling, and planning
- Water utilities are not facing a death spiral or existential threat
- Water systems should be re-optimized relative to new normals
- The water sector can lead the way from a growth to a sustainability paradigm
Thank you!