

Calculating Energy and CO2 Savings Related to Water Efficiency (the Easy Way)

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The (our!) Environment

- People are generally becoming more aware of the negative impacts our actions can have on our environment –
 - We want “green” products with less packaging and lower life-cycle costs
 - We want sustainable lifestyles
 - Popularity of “Inconvenient Truth”
 - Solar power, wind power, electric cars, etc.



Water and Energy

- Einstein discovered the relationship between mass and energy in the early 1900s
- It took us almost 100 years to discover the relationship between water and energy
- Energy is used by the water agency to:
 - collect raw water, treat water, distribute to customer
 - collect wastewater, treatment, discharge to environment
- Energy is used by customer for:
 - heating, cooling, pumping, etc.



How much energy?

- The amount of energy depends on more than just the related volume of water,
- Also depends on system characteristics:
 - Efficiency of pumps, pipes, etc.
 - Distance water is pumped,
 - Elevation to which water is pumped, etc.
- And End uses:
 - Is water heated? How hot? How heated?



Different degrees of Accuracy

- We know that we can save lumber (trees) if we build homes with studs placed on 24-inch centers vs. 16-inch centers.
 - But exactly how much lumber can we save?
- Should we obtain blue prints for all new homes being built and calculate the savings?
 - Big job!



Water Savings

- How much water can Joe save by installing an HET?
 - How many toilets in Joe's house?
 - How many people in Joe's house?
 - How many times per day does each person flush?
 - How many #1s? How many #2s?
- Lots of data required.
- Analysis not practical on large scale.
 - How much water can be saved in Canada with HETs?



Water / Energy Savings

- How much energy can be saved in Canada by switching to HETs? Front-load washers? Washing clothes with cold water? Hot water recirculation systems? Etc.
- Important to know, but not practical (and probably not possible) to determine 100% accurately.
 - Evaluate every component of every water/wastewater system in the country.



It's all about ABOUT

- Question
 - How many jelly beans are in the jar?
- Answer
 - I would say about 400 or so...
- Reply
 - NOPE! There's only 398.



Bang for the Buck...

- If there is no way to know the exact number, we need to determine the level of accuracy that we would be happy with.
- This is often related to the level of effort that would be required to move to the next level of accuracy.
 - e.g., miles of coast line
 - e.g., flush volume of a toilet



Energy Savings Choice

- Which saves more energy?
 - Reducing hot water demand of shower by 50L,
or
 - reducing irrigation by 4,000L.
- A: The shower would save about 5 kWh and the irrigation only about 2.4 kWh (half as much).
- But - how can we know this?



Let's consider what we don't know -

- We don't know:
 - where the water was produced or how far it is pumped
 - if the water was heated with an electric or gas water heater
 - the efficiency of the water heater
 - the temperature differential of the cold/hot water, etc.



Now, let's consider what we do know (more or less) -

- We have a good idea of the:
 - energy required to heat water
 - average efficiency of water heaters
 - avg. temperature differential of cold/hot water
 - percentage of electric vs. gas water heaters
 - approximate avg. energy related to water treatment/supply & wastewater collection/treatment



Hot, hot, hot

- We also know that the energy required to heat water is MUCH more than the energy required to treat/distribute water.
- In fact, it appears that – **on average** – it takes as much energy to heat about 1.0 L of water in a residential water heater as it does to treat/distribute/collect/treat about 150 L in a municipal system.



Type of savings impacts energy

- Some savings can include hot water (showers, clothes washers, dishwashers)
 - less important to know details of water/wastewater system
- Some savings can include water and wastewater (toilets, showers, etc.),
- And some just water (e.g., irrigation).
- But, what about CO₂e?



Big variations in CO₂/kWh

- The amount of CO₂e varies significantly depending on how energy is produced –
 - Hydro, oil, natural gas, nuclear, etc.
 - Can range from about 0.01 kgCO₂/kWh (hydro) to about 1.0 kgCO₂/kWh (coal)
- Not only is each Province different, but there can be differences within each Province



About...

- In most cases, however, having a Province-wide value may be ‘close enough’
- Especially if the water-efficiency program is being done on a Province-wide basis.
- By all means – if you have more accurate data, use it!



The Excel-based Calculator

- Very simple – requires minimal input
- Uses accepted values, conversions, e.g.,
 - it takes 1.0 kcal to heat 1 L of water by 1C
- Plus (from Ont. research by Carol Maas)-
 - treat/distribute 1m³ water ~ 0.60 kWh
 - reduction savings water ~ 87%
 - collect/treat 1m³ wastewater ~ 0.55 kWh
 - reduction savings wastewater ~ 8%



Calculator (con't)

- Makes assumptions that can be 'over-ridden', e.g.,:
 - Temperature differential cold/hot ~ 55C (100F)
 - Efficiency of electric water heaters ~ 88%
 - Efficiency of gas water heaters ~ 56%
 - ~ 12% line losses (electrical transmission)
 - ~ 1.93 kgCO₂/m³ natural gas combustion
 - Lists kg CO₂ / kWh for each State and Province



Calculator – example (con't)

State	kg CO2/kWh		Province	kg CO2/kWh
Alabama	0.60		B.C.	0.02
Alaska	0.69		Alberta	0.93
Arizona	0.51		Saskatchewan	0.87
Arkansas	0.55		Manitoba	0.02
California	0.27		Ontario	0.27
Colorado	0.83		Quebec	0.01
Connecticut	0.32		Nova Scotia	0.66
Delaware	0.82		New Brunswick	0.47
District of Columbia	1.22		PEI	1.18
Florida	0.57		Newfoundland	0.03
Georgia	0.65		Territories/Nunavut	0.15
U.S. Avg.	0.605		Canada Avg.	0.227



Calculator (con't)

Water savings	1,000	m ³
Wastewater savings as a percentage of Water savings	100%	see note #1
Coefficient (kg CO ₂ /kWh)	0.605	see note #2
% of total water savings that is heated	100%	see note #3
% of water heating via gas	50%	see note #4
% of water heating via elect.	50%	see note: #5
Savings	35,730.48	kg CO₂

Note #1: irrigation, evaporation, etc. = 0%, toilets, showers, etc. = 100%

Note #2: input data for your system or select Provincial/State average from above.

Note #3: irrigation, toilets, etc. = 0%, showers = a value of approx. 50%, clothes washers = a value of approx. 50%

Note #4: in some areas one type of water heater is more prevalent. If you know the approx. installed capacity, use that value.

Note #5: if 0% of water is heated, these percentages are not used in calculations.



Example 1- Irrigation

Water savings (m3)	1,000
% Wastewater	0%
Coefficient (kg CO2/kWh)	0.605
% heated	0%
% heated via gas	50%
% heated via elect.	50%
Savings (kg CO2e)	359

Breakdown of Energy Savings, kWh

municipal water	593.182
municipal wastewater	0.000
Total municipal energy	593.18
heating (gas)	0.00
heating (electricity)	0.00
total heating	0.00

Total kWh	593
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Example 2 - Toilets

Water savings (m3)	1,000
% Wastewater	100%
Coefficient (kg CO2/kWh)	0.605
% heated	0%
% heated via gas	50%
% heated via elect.	50%
Savings (kg CO2e)	389

Breakdown of Energy Savings, kWh

municipal water	593.182
municipal wastewater	50.000
Total municipal energy	643.18

heating (gas)	0.00
heating (electricity)	0.00
total heating	0.00

Total kWh	643
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Example 3 - Showers

Water savings (m3)	1,000
% Wastewater	100%
Coefficient (kg CO2/kWh)	0.605
% heated	50%
% heated via gas	50%
% heated via elect.	50%
Savings (kg CO2e)	18,060

Breakdown of Energy Savings, kWh

municipal water	593.182
municipal wastewater	50.000
Total municipal energy	643.18
heating (gas)	28,548.40
heating (electricity)	20,644.50
total heating	49,192.90

Total kWh	49,836
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Daily savings if Canada (34 million persons) switched to:

- HETs ($5 \text{ F/d} \times 7 \text{ L/F} = 35 \text{ Lcd}$)
 - 173,743 kg CO₂e & 765,386 kWh
- 7.6 Lpm showerheads saving 12.8 Lcd ($75\% \times 7 \text{ min./shower} \times 1.9 \text{ Lpm}$, 60% hot water)
 - 6,065,212 kg CO₂e & 20,238,622 kWh
- Efficient irrigation ($170 \text{ L/day} \times 50\% = 85 \text{ Lcd}$)
 - 389,145 kg CO₂e & 1,714,395 kWh



Conclusions

- Can do calculations on a State-by-State or Province-by-Province basis
 - Or on a National basis
 - Or on a system-by-system basis
- Simple enough for average person to use
- A simple tool to help water agencies and governments prioritize water conservation projects and programs



Thank you...

Contact...

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