A Cradle-to-Gate Life Cycle Assessment of a Groundwater Supply System

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Research Goals

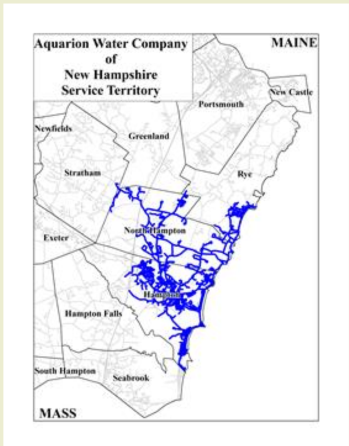
- Assess embodied energy of a groundwater supply system.
  - Quantify and compare the energy needed to directly and indirectly supply drinking water.
  - Analyze and identify the parts of a water supply system that contribute high impacts/burdens to the environment.

Background Information

The concern for water sustainability has prompted the use of life-cycle assessment (LCA) – a tool that allows scientists to measure the energy demands and environmental impacts of inputs and outputs of a system. This information is then used to guide discussions and decisions on how to improve or enhance the various aspects of that system.

In this case study, SimaPro software (often used for LCA) was used to assess energy consumption by Aquarion -a seacoast water supply company- to supply treated groundwater to their service territory for one year.

- direct energy (electricity needed for operating the system)
- indirect energy (energy related to the production of chemicals and materials and the construction of the system)



Methods

- A tour was conducted to learn about the process of producing drinking water -from water supply through treatment and finally to distribution.
- A questionnaire was created and provided to Aquarion to collect data concerning all major parts of their supply process.
- A life-cycle assessment was conducted with the data to analyze both direct and indirect energy and determine potential environmental impacts associated with each.

Drinking Water Supply Process

Supply

Intake of water from aquifer with pumps

1

Treatment

Chlorine to disinfect & other chemicals for corrosion control

2a

2b

Transformer & Generator to supply the energy (electricity)

Distribution

Water delivery directly after treatment

Storage – this tank holds 1 million gallons of treated water

Tour Begins at Well #9 Pump House

4

Distribution

Underground pipes feed homes and businesses

3

Boosters- pump water from tank to distribution mains

Results

Direct & Indirect Energy Data

Direct Energy - Electricity

Electricity Data	Calculation
\$206,700 – power budgeted for year 2014	\$206,700 ÷ .12/kWh = **1,722,500 kWh/year** *Industry kWh -\$ .12 on average*

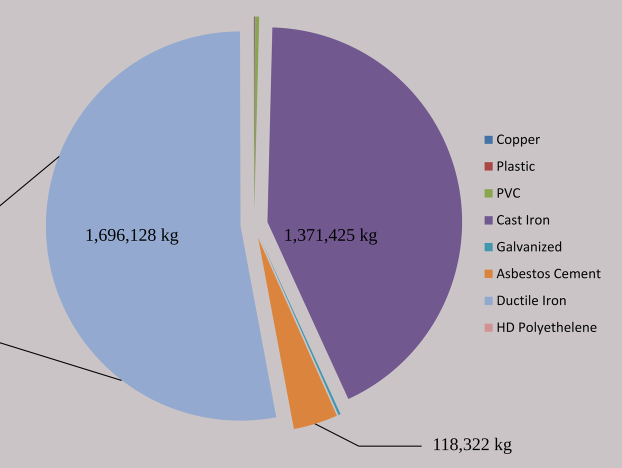
*System Boundary:

- Natural gas and LP data not available

Indirect Energy – Structural/Materials

Chemical Data (averages between 2006 -2013)		Calculations
Chlorine	5,007 gal/year	10.03 lbs/gal x 5007 = **50,220 lbs/year**
Sodium Hydroxide	4,008 gal/year	10.12 lbs/gal x 4008 = **40,560 lbs/year**
Phosphate	**11,063 lbs/year**	

Infrastructure Data	Amount
Pumping Stations	**8 (~70 year lifespan)**
Storage Tanks	**4 (~70 year lifespan)**
Pumps	**12 (~20 year lifespan)**
Non-Residential Bldg.	**1**
Piping Material	**Total kilograms of each type calculated (M = D x V)**



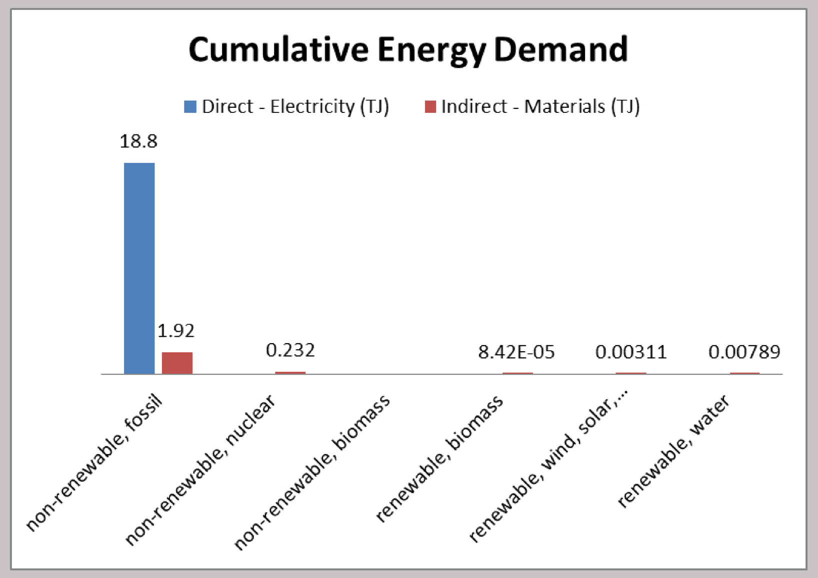
*Assumptions:

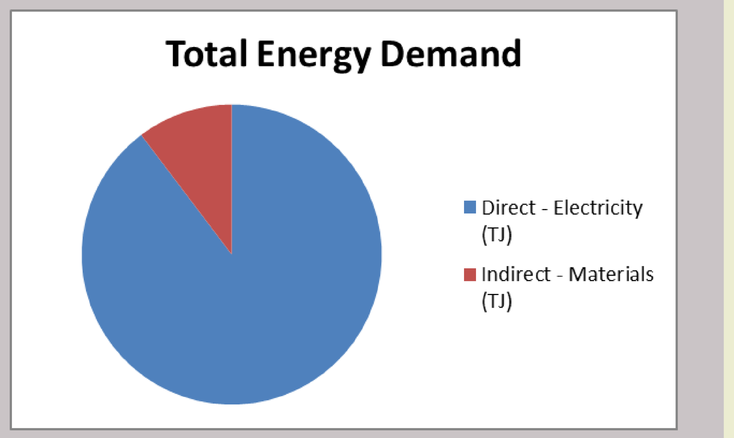
- Common thickness of pipe to be .14 inches
- Piping material will last to high end of lifespan range

*System Boundaries:

- Number & material type of fittings, valves, and valve boxes not available

Comparison of Direct Energy vs. Indirect Energy

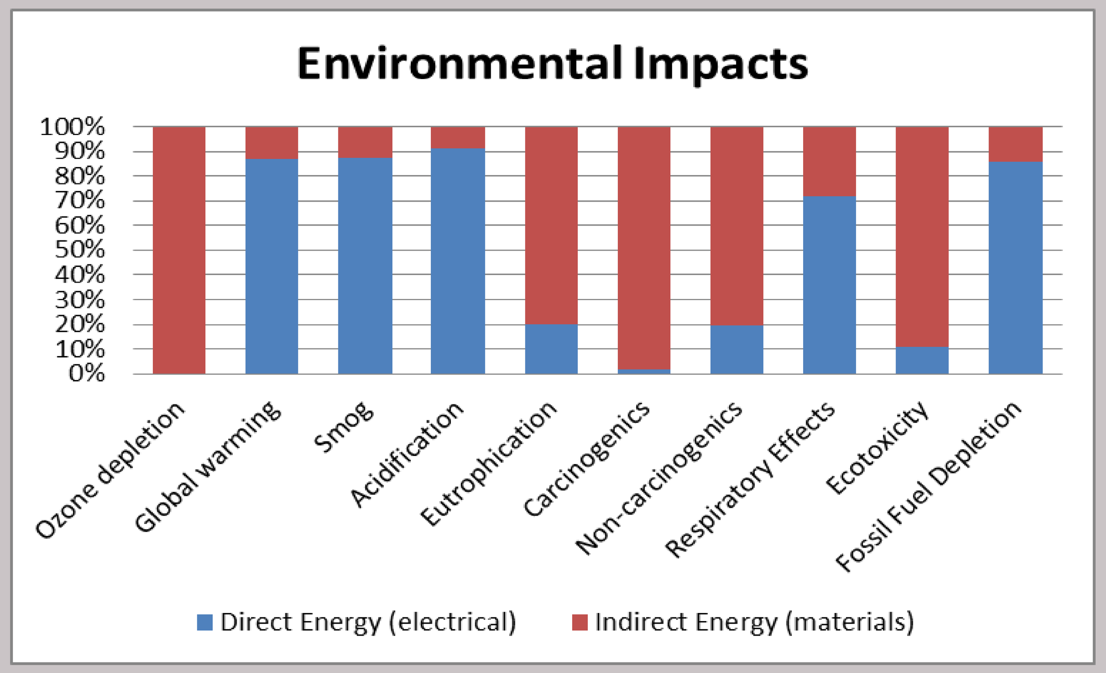




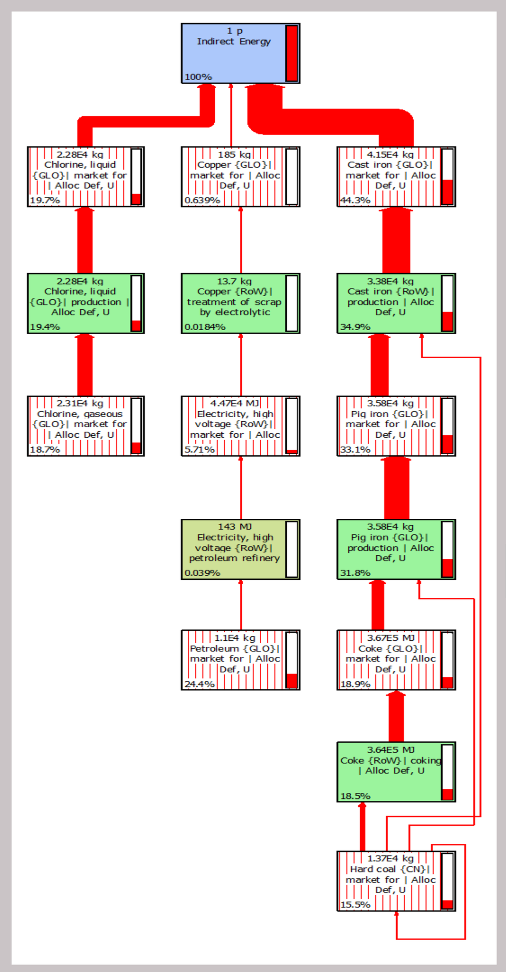
~ 90% of total energy demand comes from electricity needed to basically move water around system.

North American TRACI method

- developed by the US Environmental Protection Agency
- assesses potential for environmental impacts associated with making a product



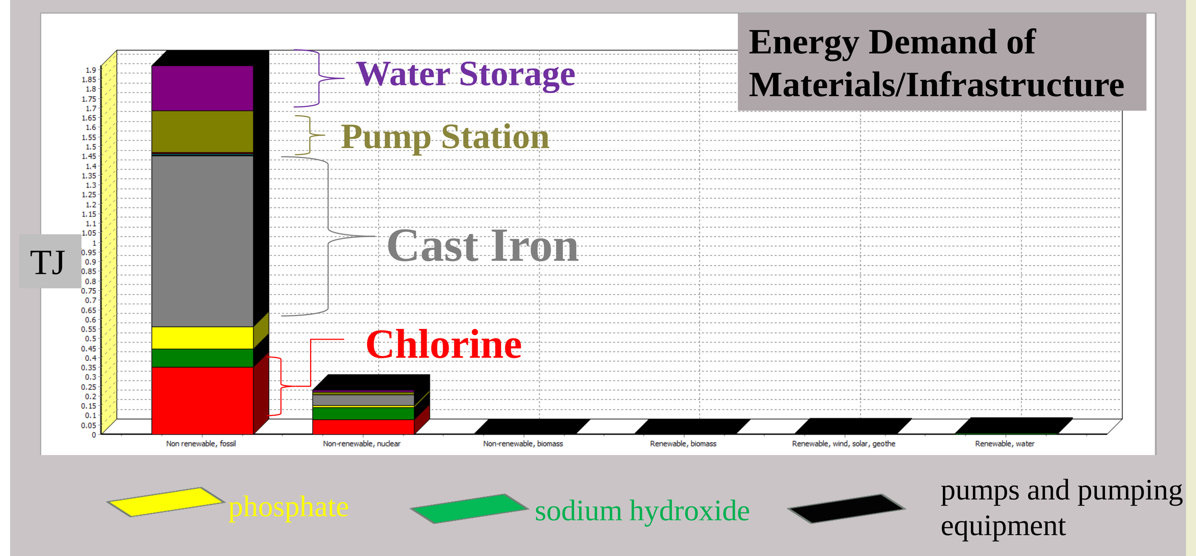
Analysis of Indirect Energy (Materials & Infrastructure)



**Note: this is a partial network showing only 16 of 8,311 products and their processes.*

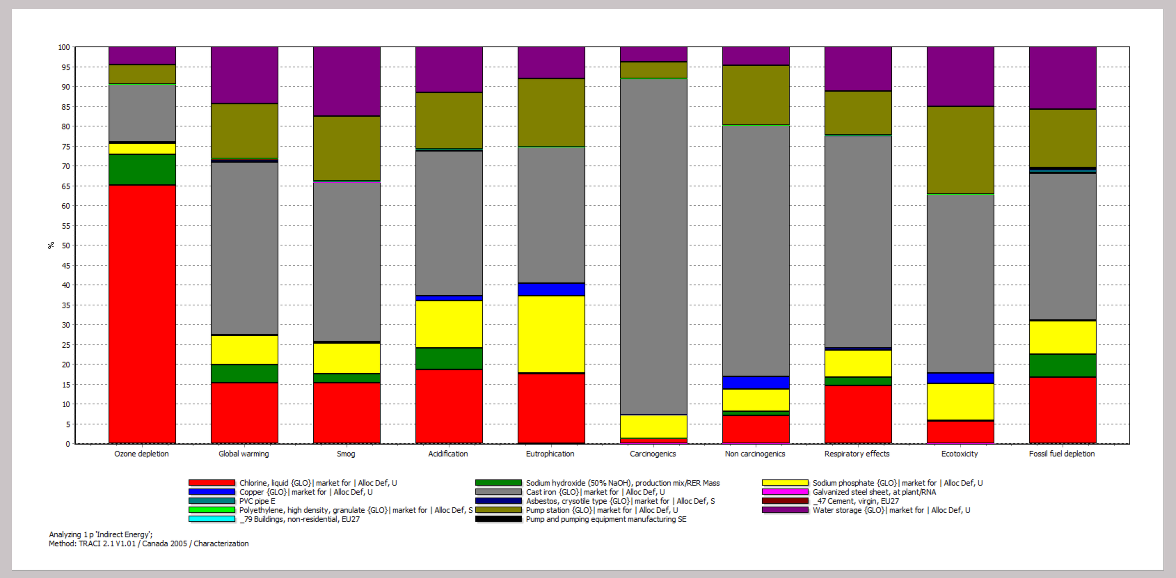
Arrows – indicate direction & environmental load

Thermometers - indicate environmental load generated



Approximately ½ of the embodied energy of this supply system comes from the products and processes associated with iron and chlorine

Environmental Impacts Related to Materials & Infrastructure



Products & processes associated with iron and chlorine contribute the most to the environmental impacts.

Summary

- Non-renewable energy used directly to operate and maintain system constitutes most of the embodied energy.
- Products and processes involved with direct and indirect energy impact the environment in varying degrees.
- Materials such as iron and chlorine rank highest in indirect energy demand and environmental impacts.
- Infrastructure including pump stations and tanks contribute significantly to both indirect energy and environmental impacts.

References

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