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Carbon Footprint Analysis of Geothermal Heated Airport Pavements

Background

- ❑ Global warming is a serious and well-known environmental issue
- ❑ Innovation is needed in reducing/mitigating carbon emissions from man-made processes and systems

Snow Removal Systems

Geothermal heated pavement systems (GHPS)

Circulate fluid warmed up by geothermal energy in pipes that have been embedded in or below the pavement

Direct exchange geothermal system by electric pump

http://www.globalpipe.de/wp-content/uploads/Schuetz-eu-flugh_Bild2-1.jpg

http://geothermalflowcenters.com/wp-content/uploads/2013/09/geothermal_flow_center.jpg

Traditional snow removal systems

Apply chemical/mechanical equipment to remove snow, and prevent snow forming on airports

http://www.battsinc.com/03Images/4k75DI04.jpg

- **Snow plows**
- **Snow blowers**
- **Chemical sprayers**

http://i.usatoday.net/travel/_photos/2011/01/18/denverx-topper-medium.jpg

http://upload.wikimedia.org/wikipedia/commons/8/89/Oshkosh_snow_removal_vehicles.JPG

Objective

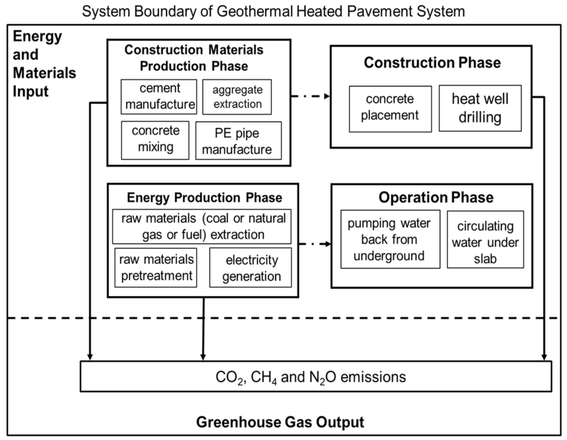
Compare greenhouse gas (GHG) emissions (CO_2, CH_4, and N_2O) produced from geothermal heated pavement systems and traditional snow removal systems

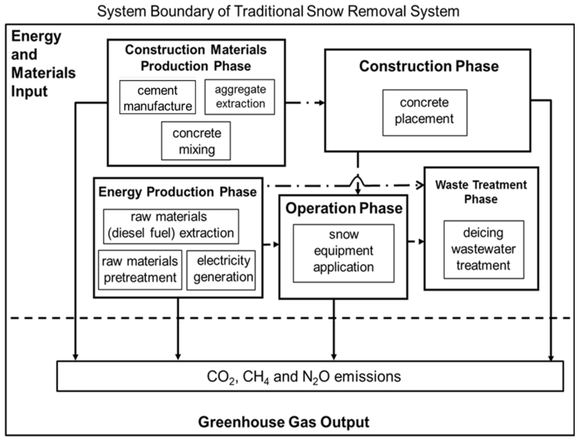
Life Cycle Assessment (LCA)

LCA is a well-developed assessment methodology for estimating and analyzing the environmental impacts of products from raw material to end production

System Boundary

System boundaries are established to identify GHG generation processes for both snow removal systems





Comparison Results

Both snow removal systems are applied to remove 1-in. depth of snow

Life Cycle Phases (20 year time frame)		GHG emissions (tCO_2eq/day)
Construction materials production	Pavement construction materials manufacturing	2.33
	PE pipe manufacturing	5.89×10^{-3}
Construction	Concrete placement	4.60×10^{-2}
	Heat well drilling	5.76×10^{-3}
Energy production	Coal power plant	5.46
	Natural gas power plant	2.32
	Fuel power plant	4.30
Total	Case 1: use of energy generated by coal power plant	7.85
	Case 2: use of energy generated by natural gas power plant	4.71
	Case 3: use of energy generated by fuel power plant	6.69

Life Cycle Phases (20 year time frame)			GHG emissions (tCO_2eq/day)
Construction materials production	Pavement construction materials manufacturing		2.33
Construction	Concrete placement		4.60×10^{-2}
Energy Production	Diesel fuel manufacture		1.70×10^{-2}
	Electricity for wastewater treatment	Coal power plant	5.83
		Natural gas power plant	2.85
		Distillate oil power plant	4.74
Operation	Snow equipment application		6.20×10^{-1}
Total	Case 1: use of energy generated by coal power plant		8.21
	Case 2: use of energy generated by natural gas power plant		5.23
	Case 3: use of energy generated by distillate oil power plant		7.12

Key Findings

- ❑ **GHPS slightly less produce GHG emissions**
- ❑ **Major of GHG emissions**
  - **GHPS: energy production and operation**
  - **Traditional system: Deicer treatment**
- ❑ **Increasing geothermal energy extraction efficiency can reduce GHG emissions**

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