Costs and Economic, Social, and Environmental Benefits of Nationwide Geothermal Heat Pump Deployment

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Project Objective

To measure the costs and economic, social, and environmental benefits of nationwide geothermal heat pump (GHP) deployment. Analysis based on existing industry and models.

Funding through DOE solicitation DE-FOA-0000075, Award DE-EE0002741

Project timeline: 29 January 2010 - 31 January 2013

Although Geothermal Heat Pumps are now in the Building Technologies Program, the project is funded through the Geothermal Technologies Program.

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Project Purpose

Addresses findings of Patrick Hughes' (ORNL) 2008 study

- –Need to assemble independent, hard data on costs and benefits of GHPs
- –Need to independently assess the national benefits of GHP deployment

First effort to quantify the entire extant GHP chain (Manufacturing, Design, and Installation) and establish impacts (job creation, revenue generation, national energy and GHG consequences). This effort is complimentary to that of Liu (ORNL, 2010) who used EIA data to examine impacts of nationally retrofitting of residential buildings.

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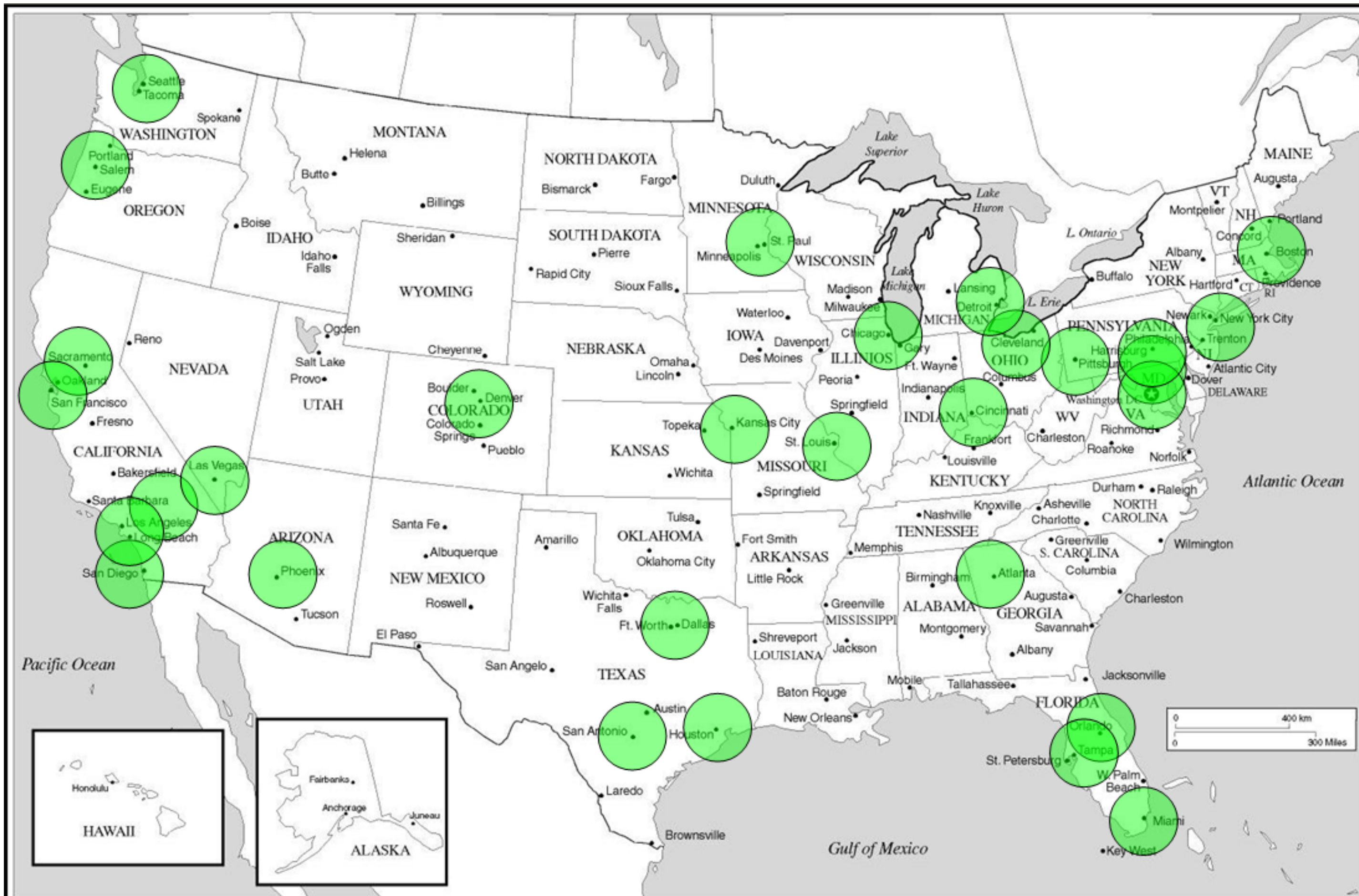
Evaluating 30 largest metropolitan areas



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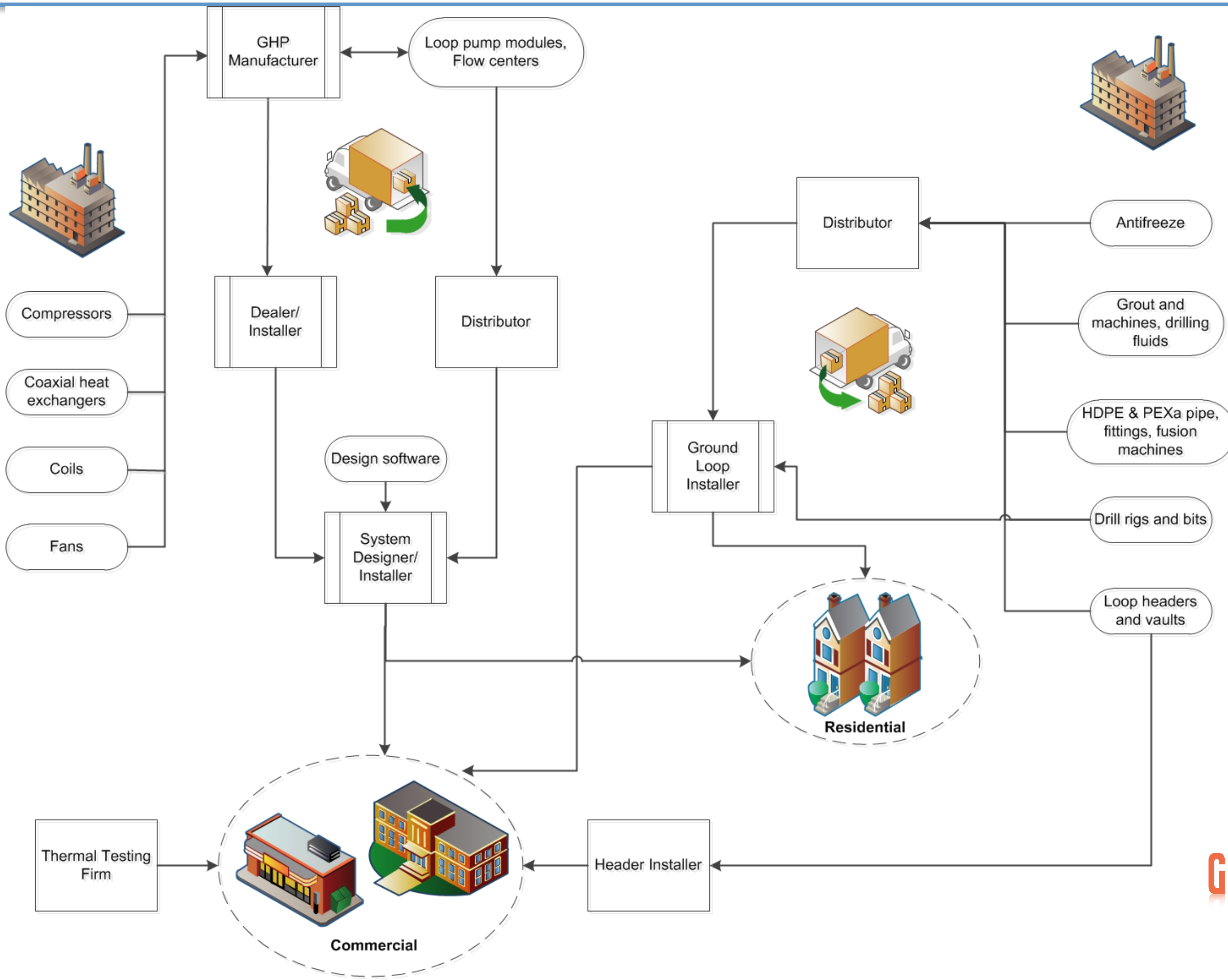
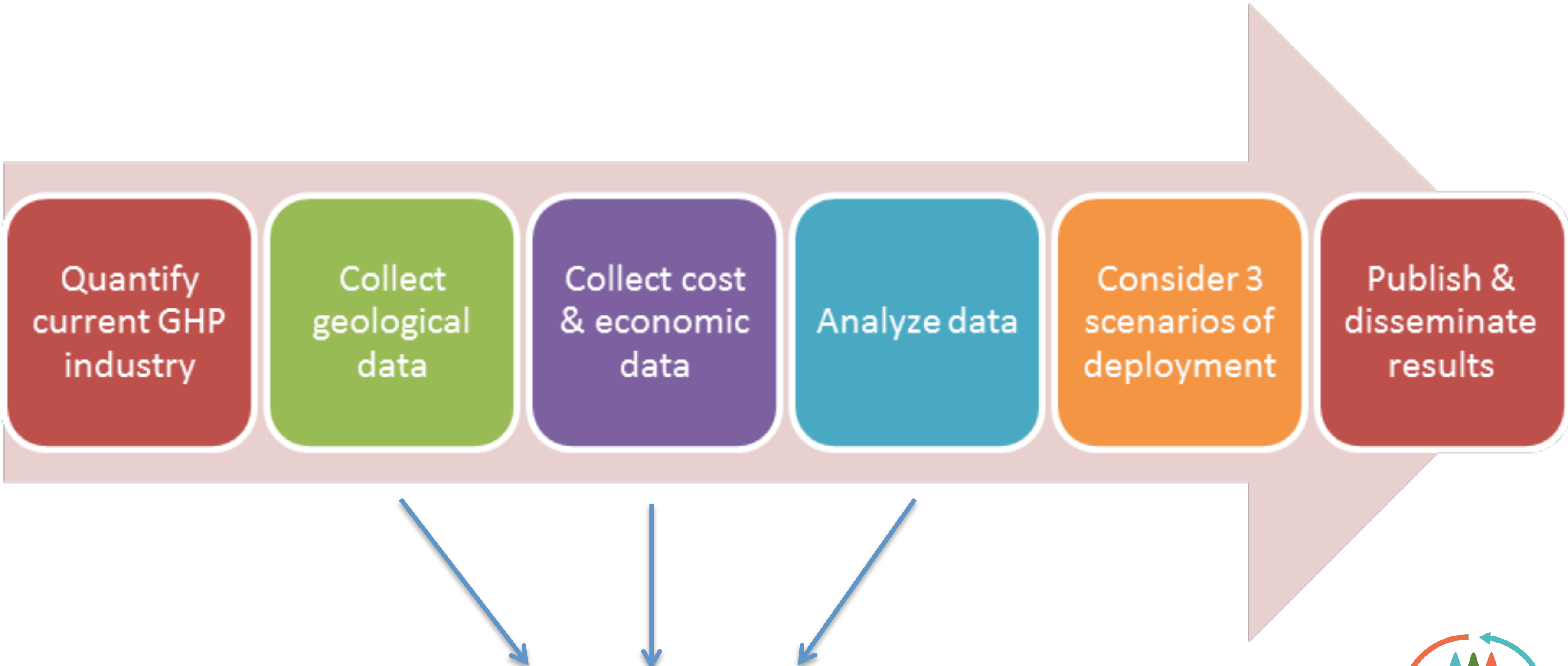
Economic forecasting is an attempt to make astrology look respectable.

John Kenneth Galbraith

GHP industry components in this study



Overall Approach



The topics of this presentation

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General Methodology

For instances in which historical data for installations is inadequate, we have undertaken the following approach:

1. Obtain data on subsurface temperature, weather, geology, thermal conductivity (Tc) and thermal diffusivity data for metropolitan areas.

2. Compute heating and cooling loads using EnergyPlus (EERE).

3. Using a standardized modeling approach for loop design, conduct simulations and sensitivity studies. (Gaia Geothermal Ground Loop Design (GLD) 2010 Premier software package).

Considering 1 residential building and 1 commercial building for each metropolitan area.

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Data sources

Subsurface temperatures obtained from McQuay International, 2002, AG31-008. But, there are caveats.

Thermal conductivities from multiple sources, mainly USGS reports and international literature.

Thermal diffusivity obtained by fitting linear curve to Tc vs Td data from *Cermak, V. and Rybach, L., 1982. Thermal conductivity of minerals and rocks.*

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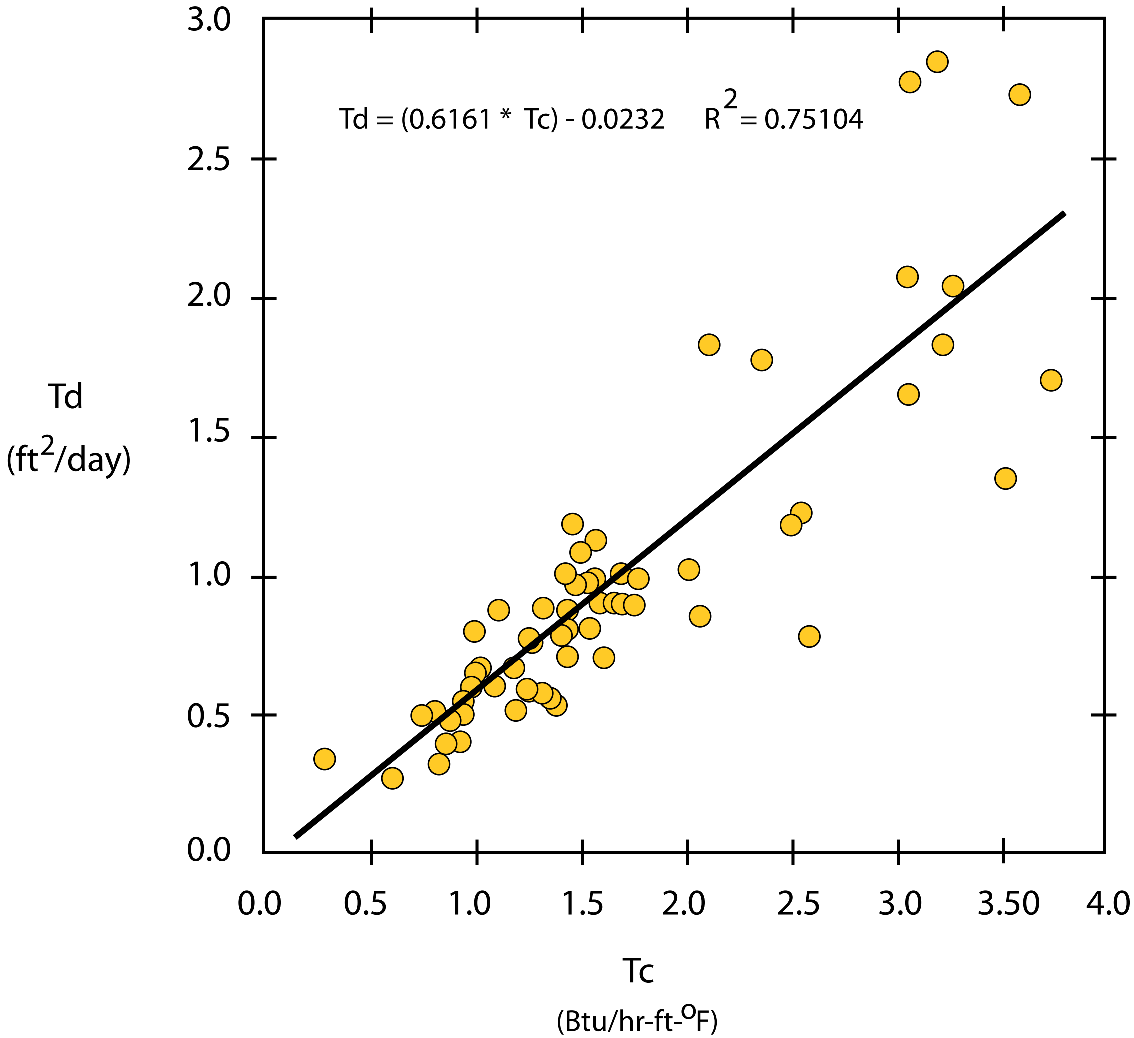
Correlation between thermal conductivity and thermal diffusivity



Load considerations

For residential and commercial model:

- Use EnergyPlus (NREL/EERE) to compute loads, by city and month. Control for:
  - Window/wall area ratio
  - Orientation
  - Insulation
  - Lighting
  - Human load
  - Zones
  - Appliances
- Compute daily, hourly and annual max loads, based on local energy use patterns (FERC data base).

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Example results

Consider Los Angeles and New York as examples because of contrasting climate, energy sources and geology.

Computed loop lengths based on EnergyPlus loads, as a function of thermal conductivity, and uncertainty envelopes.

Also computed CO_2 emissions reductions, based on reductions in energy consumption.

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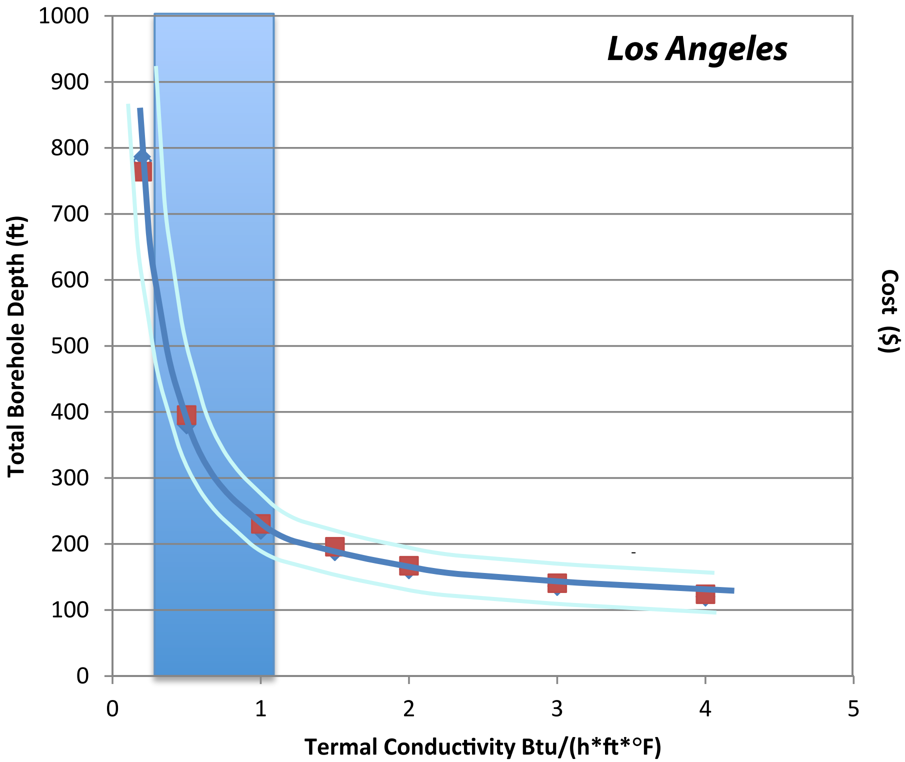
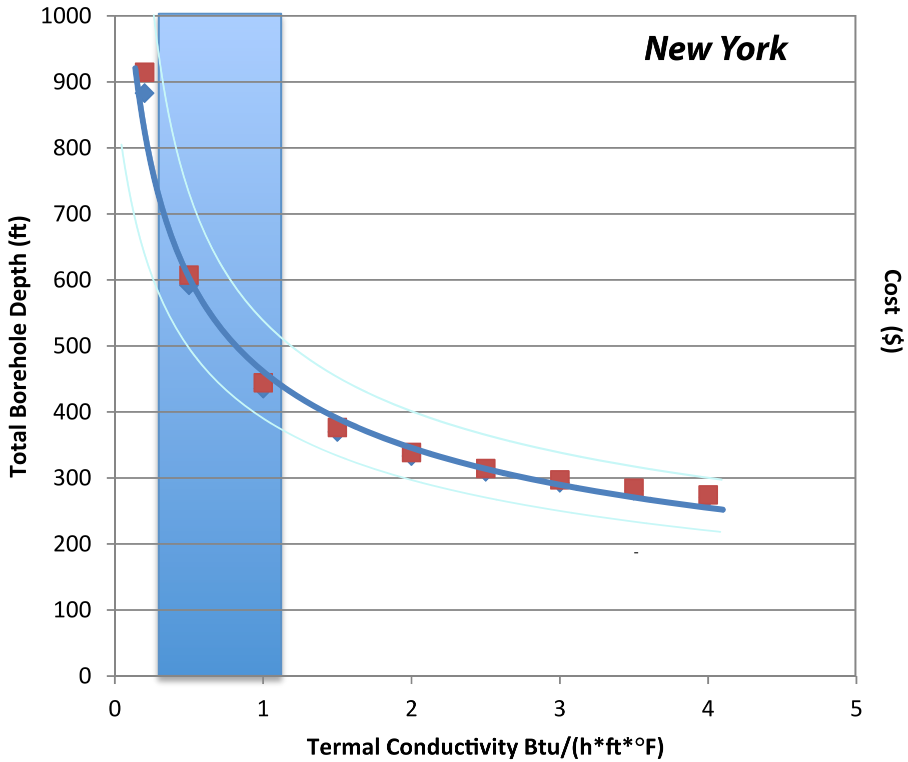
Typical results for 1,980 ft^2 home: Borehole depths vs Tc for Los Angeles and New York





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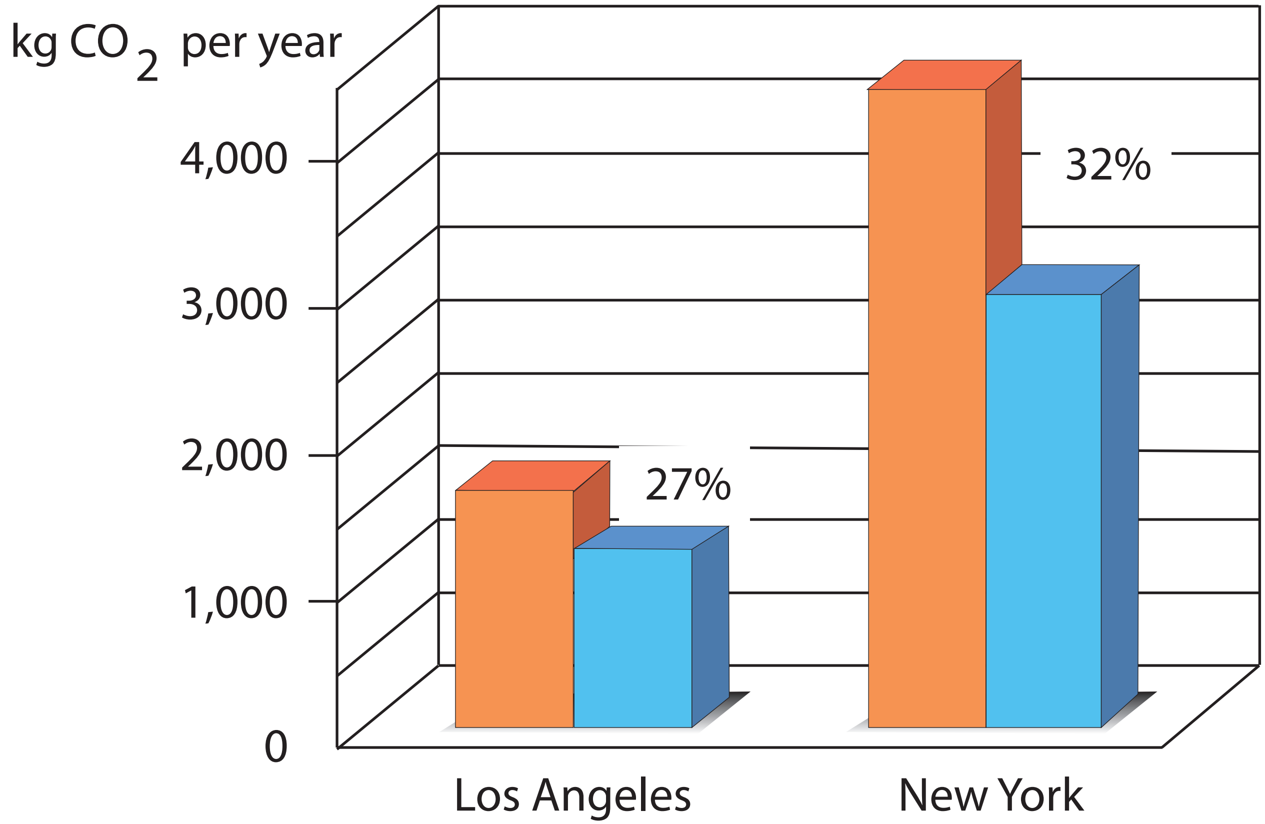
Regardless of climate zone, GHP installation significantly reduces GHG emissions



Orange is conventional HVAC system typical for area; blue is GHP system

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Concluding remarks

Compilation of results for the 30 metropolitan areas will be completed in mid-2012. Results will include costs estimates, an analysis of simple payback time, and impacts on national and local GHG emissions.

But, we need more data on thermal conductivity/diffusivity, and costs ($/borehole length; $/completed installation) in order to better quantify payback time. Any assistance you can provide can be sent to either:

Bill Glassley – geobg@nf.au.dk or
Liz Battocletti - info@ghpsrus.com

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