Grid Cost and Emissions Reduction Through Mass Deployment of Geothermal Heat Pumps for Buildings in the USA

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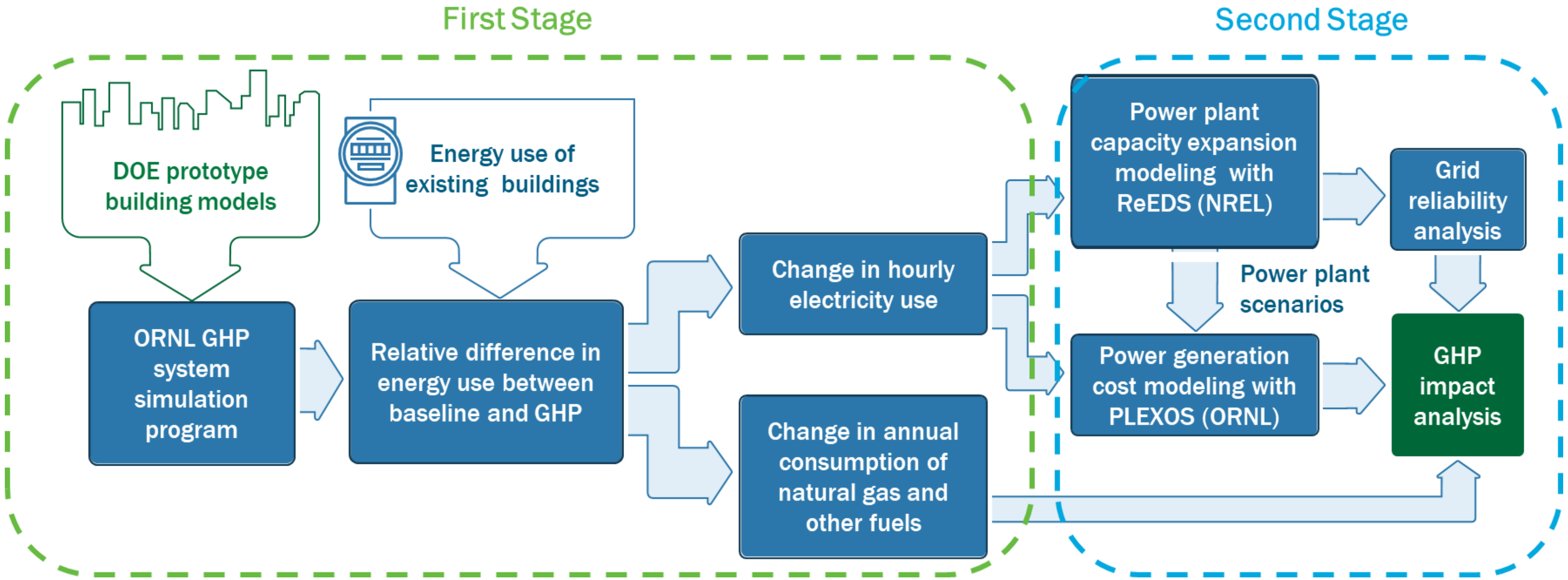
Objective and Approach

Objective: Evaluate the grid cost and emissions reduction with mass deployment of geothermal heat pumps for buildings

Approaches:

- Simulate the impacts on energy use by retrofitting various existing **commercial and residential buildings** with Geothermal Heat Pump (GHP) systems in 15 climate zones in the United States.
- Through **capacity expansion modeling** and **production cost modeling** of the US electric power sector, assess the impacts of a national deployment of GHP systems on the US electric power system.



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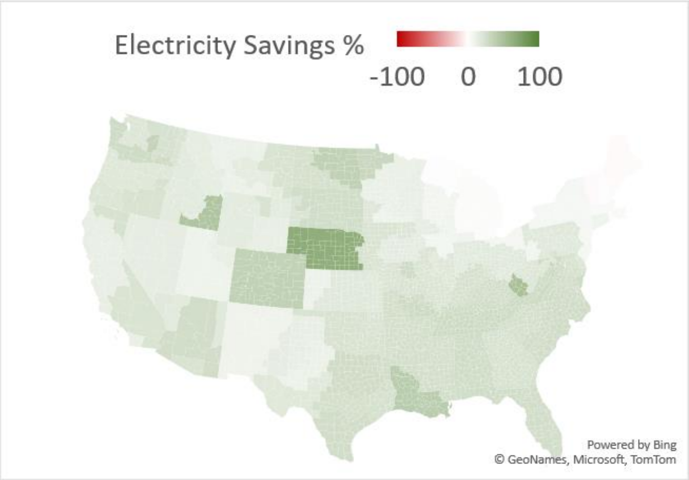
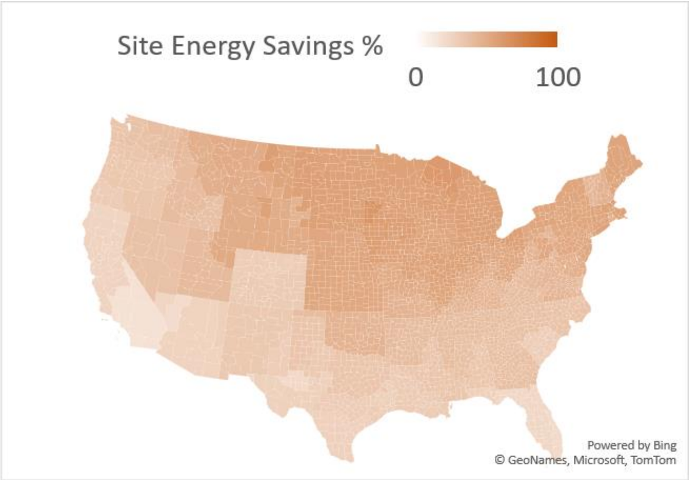
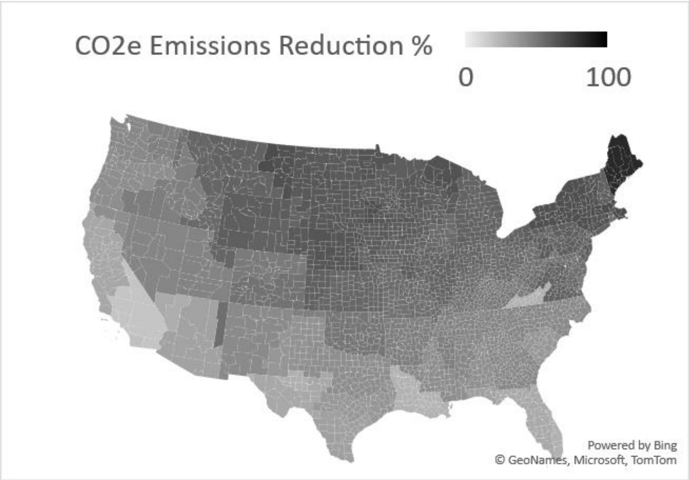
Results of Building Sector

- Save 429 billion kWh of electricity (a 19% reduction from the baseline EULP) each year.
- Reduce 496 million MT of carbon emission (a 36% reduction from baseline) each year.
- Observe that changes in electricity consumption in each BA depend on building floor area (population), weather (climate zone), and fuels used in existing buildings for space heating/cooling.
    - More effective in cold climates for reducing site energy consumption and carbon emissions.
    - More electricity savings in the southern part of the country. The peak demand reduction is high at the population center in the South.







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Results of Electric Power Sector

Simulation Results of the Base Scenario and Base + GHP Scenario.

Electricity-related simulation results

	Base	Base + GHP	Reduction	Reduction ratio (%)
Annual load demand (TWh)	5,709	5,091	618	10.8
Annual consumer payment (10^9 $)	182	125	57	31.5
Average electricity price ($/MWh)	32	24	8	23.2
Annual reserve provision (TWh)	457	413	44	9.5
Annual demand unserved (GWh)	4	0	4	100.0
Annual peak demand (GW)	963	839	124	12.9
Generation power capacity (GW)	1,855	1,677	178	9.6
Battery energy capacity (GWh)	3,036	2,626	410	13.5

Emission-related simulation results

	Base	Base + GHP	Reduction	Reduction ratio (%)
Annual CH4 (MT)	3,929	3,579	350	8.90
Annual CO2 (106 MT)	956	786	170	17.8
Annual NOX (MT)	413	318	95	23.0
Annual SO2 (MT)	285	198	87	30.5
Annual fuel cost (109 $)	39	32	7	18.9
Annual fuel offtake (106 TJ)	24	21	3	10.3

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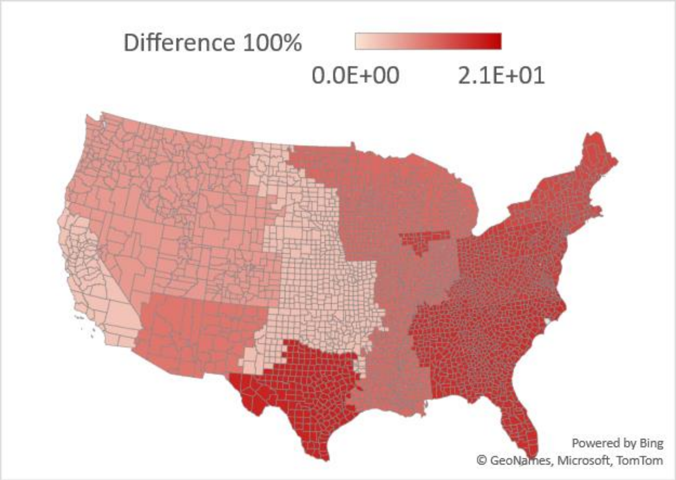
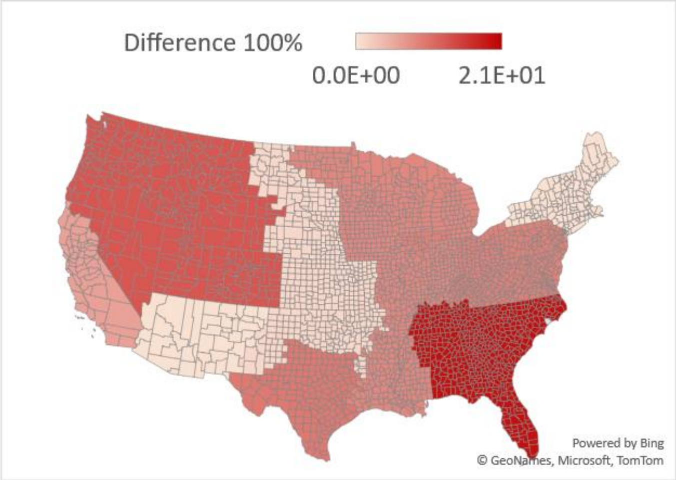
Reliability Assessment Zone Peak Load Analysis

- In summer, the peak load reduction ratio ranges from 3% to 20%. The south, southeast, and east usually have a higher peak load reduction after GHP adoption than other areas.
- In winter, peak load is less reduced in areas where fossil-fuel-based heating is widely used. The northwest and southeast have higher peak load reduction, and the northeast has the lowest peak load reduction.



Summer



Winter

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Acknowledgements

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