Feasibility of Renewable Thermal Technologies (RTT) in Connecticut

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Roadmap

- Why a feasibility study?
- What is the potential?
- How do renewable thermal technologies compete?
- What are the barriers?
- What are possible solutions?
Technical Potential
– How big is the thermal demand?

Economic Potential
– What is economically feasible given the competition analysis?

Achievable Potential
– What is realistic given barriers and drivers?
Thermal Demand in Connecticut 2014

200 trillion BTUs

- Residential (60%)
- Commercial (25%)
- Industry (15%)

12.6 million metric ton CO₂

Sources: EIA SEDS and own analysis
Demand Analysis – Main Findings

- Thermal demand in buildings is estimated to 103 – 142 trillion BTUs in 2050

- Ambitious building codes may considerably impact thermal demand, particularly in the commercial sector where the rate of new construction is expected to be high

- Higher outdoor temperatures reduce the thermal demand by 15 trillion BTUs per year by 2050

- An 80 percent reduction of the thermal demand by 2050 require a considerable number of buildings undergoing deep retrofit per year
Residential Thermal Demand Projections 2050 - Sensitivities

Market potential
Commercial Thermal Demand Projections 2050 - Sensitivities

![Bar chart showing commercial thermal demand projections from 2014 to 2050 across different scenarios, including base cases, new buildings meeting the International Energy Conservation Code (IECC), and retrofits with various energy savings. The chart includes data for heating, hot water, and cooling, with projections for 2014, 2020, 2030, 2040, and 2050.]
**Competition Analysis and Economic Potential**

- Find the financially most competitive technology for 7 archetypal customers

**Incumbent technologies**
- Fuel oil boilers
- Standard natural gas boilers
- Conventional electric technologies

**Proposed renewable technologies**
- Air source heat pumps (ASHP)
- Ground source heat pumps (GSHP)
- Solar water heating (SHW)
- Biomass pellets
- Highly efficient natural gas boilers

- Estimate the economic potential for each technology based on which is the most competitive to supply the technical potential
Single-family – Net Present Values and GHG emissions

GHG emission factors are based on the IPCC framework.

Connecticut takes a more conservative approach when accounting for emissions from biomass.
Operational Fuel Costs of Different Heating Alternatives

- Conventional electric
- ASHP
- GSHP
- Pellets
- Fuel oil
- Natural gas
- Efficient natural gas
- GSHP SolarPV @2.5$/W

$ per MMBTU

**Competitive Thermal Alternatives (Base case)**

- Heat pumps and solar water heating are competitive to conventional electric technologies

- Pellet boilers replacing fuel oil boilers are financially competitive in several commercial buildings

→ Economic potential 19%

- Highly efficient gas boilers are competitive to conventional electric and fuel oil for space and water heating

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Competition analysis

Estimated GHG Emissions of Residential Thermal Demand

Current estimate 9.1 mill ton C02e

1. Competitive RTT - an immediate reduction of 0.6 mill ton C02e
2. Competitive RTT and efficient gas boilers an immediate reduction of 2.4 mill ton C02e
3. Competitive RTT and enforced deployment of GSHPs and efficient bas boilers halves the GHG emissions
4. 75% renewable electricity add a reduction of 1.2 mill ton C02e by 2050

* GHG emission factors are based on the IPCC framework.

Connecticut takes a more conservative approach when accounting for emissions from biomass
Estimated GHG Emissions of Commercial Thermal Demand

Current estimate 3.5 mill ton C\textsubscript{02}e

1. **Competitive RTT** - an immediate reduction of 0.8 mill ton C\textsubscript{02}e

2. Competitive RTT and *efficient gas boilers* - an immediate reduction of 0.7 mill. ton C\textsubscript{02}e

3. Competitive RTT and *enforced deployment* of GSHPs and efficient bas boilers brings the GHG emissions to 65 percent

4. **75% renewable electricity** add a reduction of 0.4 mill ton C\textsubscript{02}e by 2050

* GHG emission factors are based on the IPCC framework. Connecticut takes a more conservative approach when accounting for emissions from biomass.
Sensitivity Analysis

1. Fuel costs of the incumbent technology
   a) 50 % increase
   b) 100 % increase
   of the new technology
   c) 25 % reduction
   d) Heat pumps + solar PV

2. Initial costs
   a) 25 % reduction
   b) Part load

3. Thermal Renewable Energy Credits

4. Carbon price of 41 $ per ton CO₂

5. Debt interest rate

6. Debt term

7. Combinations
### Sensitivity Analysis

**Description**

- Initial costs are 25% down
- Solar PV reduces electricity costs of heat pumps by 25%
- Fossil fuel costs are 50% up

An increasing number of RTTs become competitive against fuel oil
High upfront costs

“We cannot afford to pay extra for environmental value, and the project has to be ‘Zero out of pocket’”

Institutional customer

“... The problem is: when you put everything up on your roof, there's an outlay of money - and you're cash poor until the tax rebate is returned”

Residential customer
Cash Flow Analysis

Single-family Home Replacing Conventional Electric by GSHP*

Challenges and opportunities

- Solarize for thermal subsidies
- Tax Credits
- Packaging Solar PV
- Carbon Price
- Thermal RECs
- Interest rates
- Financing products
- Debt Ratio
- Leasing
- Thermal service agreements

* Changes are cumulative
 Awareness

“PV is killing solar thermal. The payback [for solar thermal technologies] with the tax credit is good, but it's not as sexy as PV”

Installer solar thermal

“When we talk to customers after the fact, they never talk about energy savings. They are always thrilled about how comfortable/quiet the home now feels. It’s an interesting transformation— ‘forget the savings, we love how comfortable our home is’”

Program administrator
Industry business models

“ESCOs are typically incentivized to choose projects that are most easily executed and can guarantee savings with relatively short payback periods”

“The work force needs to be developed”
Institutional customer

“Investments were synergistic. As geothermal becomes more efficient, so does use of Solar PV, which made spray foam insulation in the attic a good investment”
Residential customer
Conclusions

Achieving the targeted greenhouse gas emission depends on considerable

• reduction in thermal demand

• deployment of renewable thermal technologies

• de-carbonization of electricity generation

• and highly efficient natural gas boilers where natural gas is applied
Many thanks to Yale students that have contributed to the study

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Prabudh Goel   Krizstina Pjeczka

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